VOL. XXV. — No. 2. February 1948.

BULLETIN
OF THE
INTERNATIONAL RAILWAY CONGRESS
ASSOCIATION
(ENGLISH EDITION)

[621 .337]

Individual axle drive.

Mechanical systems used on electric locomotives and railcars, with an indication of the results obtained in service on railways of all kinds,

(Continued)*

by ADOLPHE-M. HUG,

Consulting Engineer, of Thalwil, (Zurich) Switzerland.

Chapter IV. *(Continued)*

DRIVING MECHANISM USING SPRINGS (OR RUBBER) WITH TRANSMISSION BY GEARS.

Under 4° (**). — The applications mentioned at the end of the second and beginning of the third pages of this Chapter were noted in **Cde. indiv.** on the subject of « quill cup drive ». The texts of figs. 81 and 109 of **Cde. indiv.** are only partly correct, insofar as this mechanism has been used only on the P-5 class, 2-C_0-2 type locomotive of the Pennsylvania Railroad shewn in fig. 164 of **Cde. indiv.**, whilst the ten locomotives, Nos. 10300 to 10309 (1922 — not 1920), type 2-C_0-1+1-C_0-2 of the « Chicago, Milwaukee, St. Paul and Pacific RR » (mentioned on pages 38 and 49 of **Cde. indiv.**, fig. 79, p. 39, shewing one of the bogies) have mechanism as shewn in fig. 67 below. This is probably the first « quill cup drive » with gears, developed from that used previously on the « gearless » type locomotive, No. 10002 of the PRR. Figs. 68 and 69 shew a spring unit of fig. 67 assembled and dismantled respectively.

The AEG-Kleinow mechanism, called the « Federtopfantrieb » rather seems to be derived from the first American applications, since the first locomotives of the « Reichsbahn » (DRG, later DR) fitted with this arrangement were not put into service until 1925/26. Moreover, as can be seen more particularly in figs. 104 and 105 of **Cde. indiv.** (p. 47), the joint between the two parts of the carrying boxes

(*) See *Bulletin of the International Railway Congress Association*, Nos. of September, October and December 1947, pp. 823, 885 and 999 respectively.

(**) See headings at commencement of this Chapter.

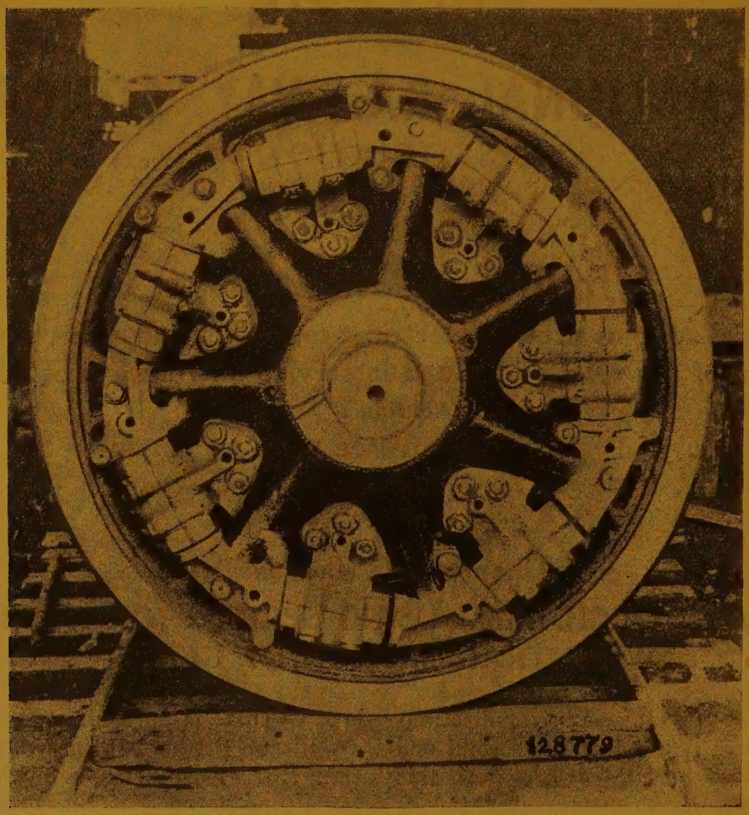


Fig. 67. — Driving axle of the 10 locomotives, Nos. 10300 to 10309, type 2-C_0-1+1-C_0-2, 1922, of the Chicago, Milwaukee, St. Paul and Pacific Railroad. Original quill cup drive. Compare with fig. 79, p. 39, of **Cde. indiv.** Odd number of couples (= 7).

(couples divided longitudinally) of the coil springs is perpendicular to the axis of the axle as on the locomotive mentioned, « Pennsylvania RR » No. 10002, which preceded it by about ten years ([50]).

In the first American applications, support for the couples was, by contrast, as shewn in fig. 67, divided along tangents to the circle of rotation of the tyre (joint being parallel to a horizontal axis of the couples and springs); the fixing bolts were accordingly arranged in the line of traction. This arrangement has not, however, been generally used in

([50]) In the 1936 supplement, « Das Elektrische Eisenbahnwesen in Gegenwart », to *Elektrische Bahnen*, Berlin, the German arrangement is called « Westinghouse-Kleinow » (p. 98 — right column). Following the intervention of Siemens-Schuckert (SSW) it was called « Einheitsfedertopfantrieb ».

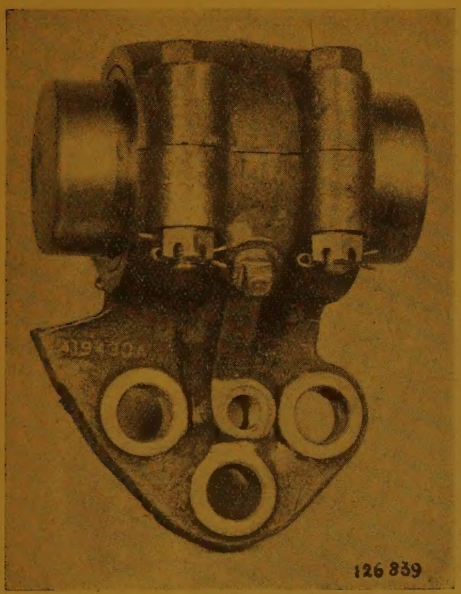


Fig. 68. — Couple and bracket in two parts (tangential joint along direction of rotation) as used on axle in fig. 67.

America and quickly gave way to the « monobloc » support, patented at that time by Westinghouse, to avoid dividing the carrying box of the couples and to provide a more rigid assembly. This arrangement can already be seen in fig. 81 of **Cde. indiv.** This mechanism, with « monobloc » support had, by 1937, been used on 173 locomotives, of which 155 were American and 18 French (Table A).

Figs. 70 and 71 shew details of the device as used on P5 class locomotives, 2-C_0-2 type, of the PRR. Later the Pennsylvania RR used rubber insertion in place of couples and springs; this development will be discussed later. Figs. 72 and 73 shew locomotives of the same Company with quill cup drive.

Table A shews the principal applications up to date of the various arrangements of couples, and completes that on p. 52 of **Cde. indiv.** ([51]). Under item 8

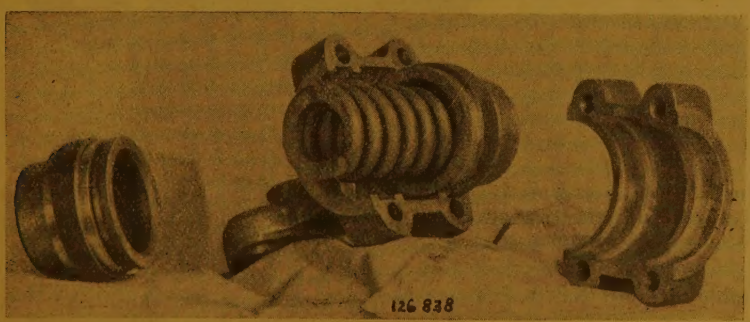


Fig. 69. — Dismantled components of couple shewn in fig. 68.

([51]) In the table in **Cde. indiv.** (see also yellow sheet of Amendments and corrections) 7 locomotives of 1911-17, Nos. 5000-5006, type 1-B_0+B_0-1, of the Boston and Maine RR. (USA) with original Westinghouse geared quill drive were omitted. — With reference to the history of coil (helical) springs, see pp. 93-94 of Vol. 1, « Conférences sur la Traction électrique », by H. PARODI, « Ecole Supérieure d'Electricité » (Société Française des Electriciens), Paris, 1936-37.

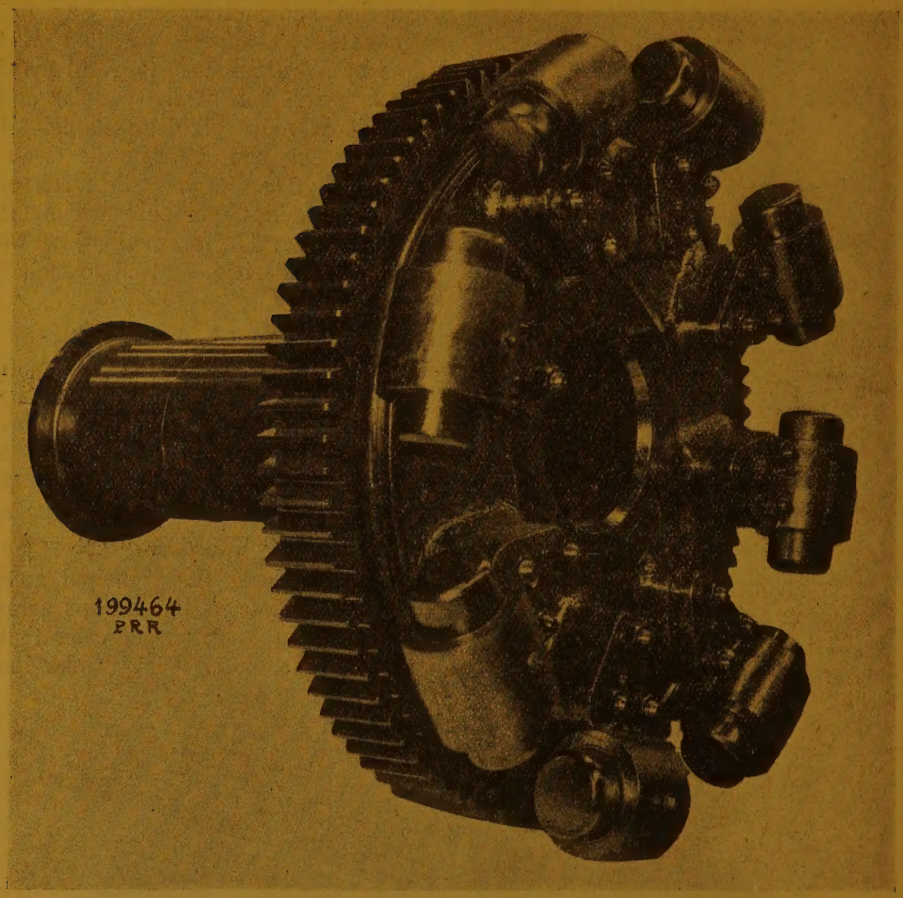


Fig. 70. — Quill cup drive mechanism, with monobloc supports, of P5, 2-C_0-2, locomotives of Pennsylvania Railroad. The driving mechanism and gears are unilateral. Even numbers of couples (= 8). See figs 81 and 164 of **Cde. indiv.**

of this table, it will be seen that this mechanism was used in 1937 in France, on a steam turbine locomotive, which will be described later along with the recent Pennsylvania RR turbine locomotive.

Of the American locomotives shewn in the table, it may be said that :

— P5 class locomotives (type 2-C_0-2, item 2 of Table A) have driving mechanism with monobloc type couples shewn in figs. 70 and 71 (unilateral operation — despite the power of 1 250 H.P. per axle — and an even number of couples). These locomotives had, up to the end of March, 1947, completed an average mileage per locomotive of 1.1 million km. (683 509 miles);

Item No.	System.	Year put into service.	Series No.	Type.	No. of locomotives.	Remarks.
α) *USA locomotives fitted with monobloc spring housing, Westinghouse patent* (*).						
1	Pennsylvania RR.	1930	Cl.0-1	2-B_0-2	3	
2	»	1931/33	Cl.P-5 & P-5a	2-C_0-2	92	On most of these locomotives, the spring couples have, since 1938, been gradually replaced by rubber blocks, in the same way as Item 4 (GG.1 class).
3	»	1934	Cl.R1	2-D_0-2	1	Locomotive No. 4399 of the PRR.
4	»	1935	Cl.GG1 (twin motors)	2-C_0+C_0-2	58 (138)	The same remarks as for item 2. The figure in brackets shews the number in service at the end of 1946. Average mileage of the locomotives at the end of 1946 = 1.5 million km. (932 058 miles).
5	»	1937	?	1-D_0-1	1	Unilateral operation, for freight trains, designed for very heavy loads at high speeds.
6	NYNH&H RR.	1942	?	2-C_0+C_0-2	10	Bilateral transmission, unilateral gears.
β) *French locomotives with monobloc housing as under* α).						
7	P.-O. (France)	1934	E.704	2-D_0-2	1	Trial locomotive which had, at the beginning of 1937, run a mileage of 240 000 km. (149 129 miles) without overhaul or lubrication of the transmission (fig. 104).
8	P.-O.—Midi (France)	1937/39	E.705-720	2-D_0-2	16	Series built following experience with locomotive E.704 (item 7).
9	French Railways.	1939	232-Q.1	2-D-2	1	Steam turbine locomotive, ordered by the « Office Central d'Etudes de Matériel de Chemins de fer, O.C.E.M. », Paris, from Schneider Works, Le Creusot.
γ) *Locomotives fitted with AEG-Kleinow mechanism, two-part couples (divided vertically)* (**).						
10	U.S.S.R.	1935	PB21	2-C_0-2	1 ?	Number of locomotives unknown.
11	Reichsbahn	1935/45	E18; 18.01-18.53 18.201-18.208	1$D_0$1	61	Carrying axle linked with neighbouring driving axle by arrangement derived from Krauss-Helmholtz.
12	»	since 1940	E19;	1$D_0$1	4	
13	Midi (France)	1935/37	4807-4824	2-D_0-2	18	Locomotives built by CEF-Alsthom, except the last two, built by AEG on reparations account.
14	BBOe (Austria)	1937/42	1870.001-008	1$D_0$1	8	Same remark as for items 11 & 12.
15	CFR (Rumania)	1938	DE2.241	2-$D_0$1+1-D_0-2	1	Double, diesel-electric, locomotive with a total of 14 axles.
16	SJ. (Sweden)	1942/47	F, 603 and 621-641	1-D_0-1	22	With bissel trucks.

(*) 85 % of these locomotives, all for passenger service, were built jointly by PRR., Baldwin's (Philadelphia) and Westinghouse (East Pittsburgh). — (**) Type known as « Einheits-Federtonfantrieb ».

— the R1 class locomotive, type 2-D_0-2, seen in the centre of fig. 72 (item 3 of Table A) is fitted with the mechanism shewn in figs. 74 and 75, with six couples divided in a plane perpendicular to the axis of the axle (even number of couples = 6 ([51b]).

— the 2-C_0+C_0-2 locomotives, supplied by Westinghouse Electric in 1942 to the « New York, New Haven and Hart-

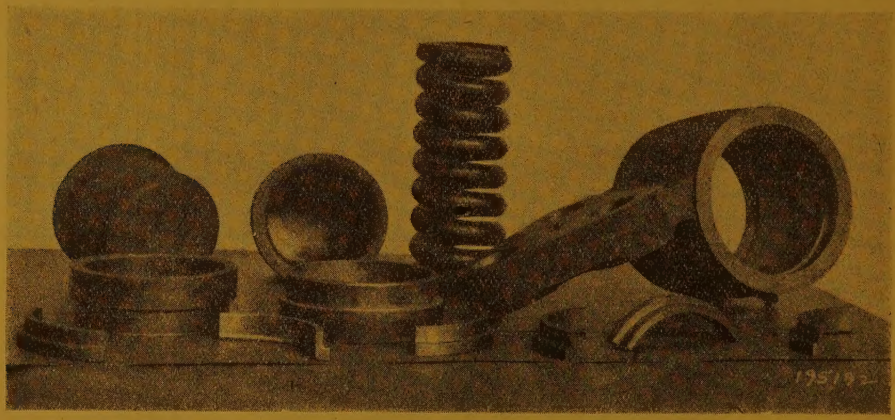


Fig. 71. — Dismantled components of couple shewn in fig. 70.

Photo Hug.

Fig. 72. — Electric locomotives with quill cup drive of the Pennsylvania RR. at the P.R.R. Sunnyside, New York, depot. In the centre is engine No. 4399, 2-D_0-2, R1 class; right, coupled to No. 4399, one half unit of a 2-C_0+C_0-2 locomotive, GG1 class, No. 4800.

Photo Hug.

Fig. 73. — View of the driving axles and equalisers of locomotive No. 4399, R1 class, type 2-D_0-2, of the P.R.R. (fig. 72). The third (conductor) rail in the foreground is used for the New York Central RR. suburban services.

([51b]) Unilateral operation. The fourth axle of this locomotive is of new construction; the large gear wheel is mounted on a roller bearing at the end of the hollow shaft, against which is placed the spider carrying the couples. This has given good service for some years, despite the increased power of 1 200 H.P. per axle.

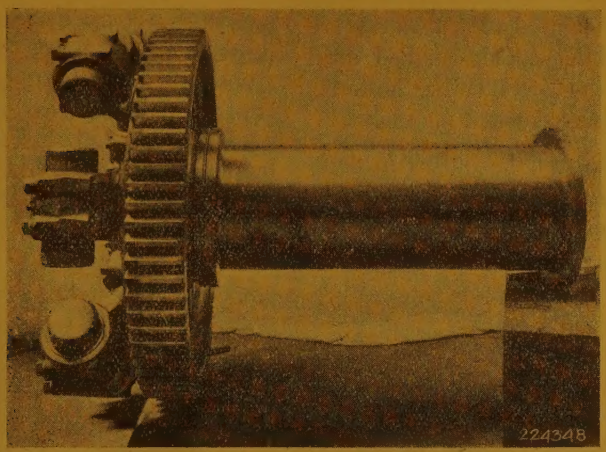


Fig. 74. — View of the hollow shaft « quill dummy-axle » of locomotive P.R.R., 2-D_0-2, locomotive No. 4399 (fig. 72, centre, and fig. 73). Even number of couples (= 6), divided at right angles to shaft axis.

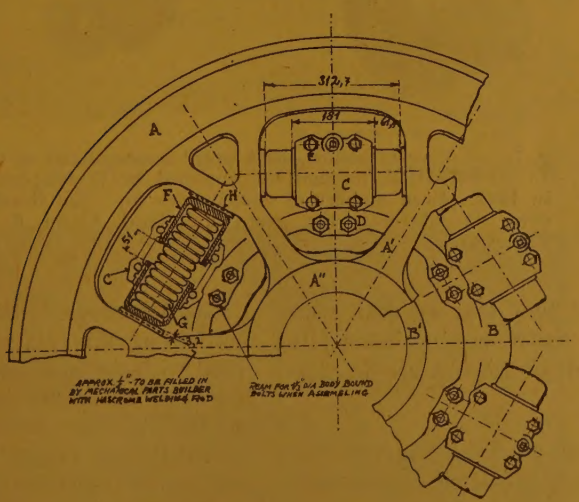


Fig. 75. — Part-elevation of driving wheel of 2-D_0-2 locomotive, No. 4399, P.R.R. (see figs. 72-74), shewing arrangement of couples — one couple with outside of casing removed;

A = wheel tyre.
A' = spoke
A'' = wheel centre.
B = crown of hollow shaft — gear wheel centre.
B' = end of hollow shaft.
C = couple bracket.
D = fixing bolts for crown B. carrying the divided couple brackets (see fig. 76).
E = bolts for couple-housing C.
F = spring cups.
G = coil spring.
H = bearing plates for cup ends.

ford RR » (item 6 of Table A) are fitted with bilateral, six-coupled, quill cup drive, the gears being, however, unilateral (figs. 76 and 77).

The French use of the quill cup drive arrangement (items 6, 7 and 13 of Table A) will be left to the end of the Chapter, so that they may be dealt with in more detail; the remaining items (10, 11, 12, 14, 15, 16) of Table A are described below :

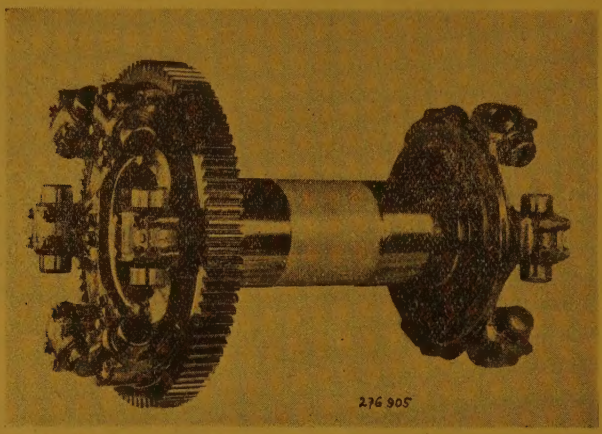


Fig. 76. — View of hollow shaft (quill dummy-axle) of the 10 NYNH&HRR. locomotives, supplied by Westinghouse in 1942. Even number of couples (= 6). The flexible drive is bilateral, the gears unilateral (Item 6 of Table A).

U.S.S.R. (item 10 Table A). — One Russian (U.S.S.R.) electric locomotive, type 2-C_0-2, for 3 000 V.D.C., was put into service in 1935. This was a PB21 class, built by the « Dynamo » and « Kolomna » Works for express service, maximum speed 130 km./h. (81 m.p.h.), hourly rating 2 800 H.P., tare 124 tons, maximum load on driving axles 23 tons ([52]).

It is not known if there are other locomotives of this class, or other classes fitted with the same mechanism ([53]). In any case, the locomotive in question was the first electric locomotive for express service in Russia; up to 1935 passenger and express services were operated by

([52]) See *Elektrische Bahnen*, Berlin, June, 1936, pp. 156-7, *Organ für die Fortschritte des Eisenbahnwesens*, Berlin, 1937, p. 90.

([53]) From the outbreak of war in Russia in 1941, it became almost impossible (and still is in 1947) to get precise information of the use in Russia of individual axle drive. — On the question of electrification, and projected extensions, in Russia, see *La Traction Electrique*, Paris, Nos. 5/6, 1935, p. 49. According to information received it appears that at the end of the 5-Year Plan, 1946-50, 7 230 km. (3 870 miles) of line should be electrified.

C_0+C_0 type freight locomotives (54) — believed to be BP22 — of which about a hundred (one publication speaks of 555 in 1947?) should now be in service (fig. 78), apart from the Diesel-electrics, of which there are now 865 (?) in service, type C_0+C_0. The $1\text{-}E_0\text{-}1$ and $2\text{-}E_0\text{-}1$ (figs. 47 to 50) are dealt with in this Chapter.

Reichsbahn DR (German State Railway) (items 11 and 12 of Table A). —

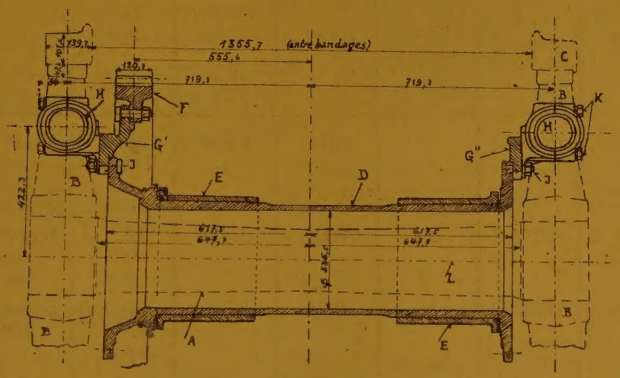


Fig. 77. — Section of hollow shaft in fig. 76, shewing wheeled axle in position.

A = axle shaft.
B = driving wheel centre.
C = tyre.
D = hollow (quill) shaft.
E = hollow shaft motor bearing.
F = geared rim.
G' = couple support (gear side).
G'' = couple support (ungeared side).
H = couples.
J = fixing bolts for couple supports.
K = bolts for half-couples.
L = centre line of axle.

Apart from the bilateral operation, this realization is absolutely similar to the one shown in fig. 75.

Fig. 78. — Electric locomotive, C_0+C_0, series BP.22(?), with individual drive, nose-suspension(?), U.S.S.R., hauling a mineral train in the Urals.

(54) See *Elektrische Bahnen*, 1934, p. 47, and 1935, p. 57. *Railway Age*, New York, 1933, 1, p. 17, Electric locomotives for Russia. *Revue Générale d'Electricité*, Paris, 1937, p. 823, Electric locomotives for hauling heavy trains on the USSR Railways.

In **Cde. indiv.** (pp. 46 and 49, figs. 102 to 108) mention was made of Reichsbahn locomotives of the following series (Table B) (55) :

TABLE B.

Series.	*Nos.*	*Year first locomotive put into service.*	*No. of locomotives.*	*Type.*	*Hourly rating* H.P.	*Max. speed* km./h.	*Remarks.*
E 21	01-02	1925/26	2	2-$D_0$1	3 800	110 *(68 m.p.h.)*	Trial engines. On 02 carrying axle with Krauss - Helmholtz fitting.
E 17 (56)	01-14 & 101-124	1928/29	38	1$D_0$1	3 800	110 *(68 m.p.h.)*	Krauss-Helmholtz fitting to two carrying axles.
E 04	01-23	1933/34	23	1$C_0$1	3 800	110/130 *(68/81 m.p.h.)*	Same leading arrangement.

Fig. 79 shews the wheel arrangement with hollow shaft and gear wheel of the leading driving axles of the E17 series (unilateral gears) and completes figs. 102 to 104 of **Cde. indiv.** (56).

Since 1933 the E18 and E19 series have been introduced, still with AEG-Kleinow (quill cup drive), both being similar to E17, but streamlined and with increased power and speed, diameter of driving wheels = 1 600 mm. (5'3").

With regard to the E18 series (57), the first locomotive was put into service in 1935 and at the beginning of 1941 29 lo-

(55) This table, with that on the following page, completes table A. Apart from the publications mentioned, a comprehensive and probably unique reference relating to the whole world, since the beginning of railway traction is provided in the book « 20 000 Schriftquellen zur Eisenbahnkunde », by Dr.-Ing. K. EWALD, edited in 1941 by Henschel and Sons, locomotive manufacturers, Cassel. The « Reichsbahn » electric locomotives are quoted on pp. 556-558. This remarkable work by K. EWALD can be usefully consulted on *all* matters concerning railway construction and operation (already referred to in note[45]).

(56) See *Elektrische Bahnen*, August 1934.

Revue Générale des Chemins de fer, April, 1935, pp. 434-436.

Zeitschrift des Vereins Deutscher Ingenieure, Berlin, Vol. 73, No. 20, pp. 670-672.

Report of Dr.-Ing. WEICHMANN on Question VII, Madrid Congress, 1930 : Electric locomotives for main line service (*Railway Congress Bulletin*, March, 1930, pp. 908-913 [already mentioned in note 9, p. 25, of **Cde. indiv.**]).

(57) See *Elektrische Bahnen*, Berlin, June, 1936, pp. 129-144, 27 figs. & 2 diagrams in colour, and the previous volume of August, 1934, pp. 163, 193 and 231. See also technical number of *Frankfurter Zeitung*, 27th June, 1935.

comotives, Nos. E18.01 to E18.29 were in service or under construction (figs. 80 and 81).

With regard to the E19 class, the first two locomotives, E19.01 and E19.02 were put into service at the beginning of 1938 ([58]). This new series was provided for main-line long-distance express trains (Fern D-Züge) of 360 tons drawbar load and a speed of 180 km./h. (112 m.p.h.), on gradients of up to 25 ‰, without stops or double heading.

The characteristics of these two series were as follows :

Fig. 79. — Driving axle with hollow shaft and unilateral gear for flexible drive, AEG-Westinghouse type, of German locomotives, E.21 and E.04 series.

TABLE C.

Series.	*Nos.*	*Year.*	*Max. speed* km./h.	*Max. speed in service* km./h.	*Hourly rating* H.P.	*Max. tractive starting effort.* kgr.	*Tare* tons.	*No. of locomotives.*
E 18	001-053 201-208	1935/45 1940/41	150 (93 m.p.h.)	140 (87 m.p.h.)	4 220	21 000	109	61
E 19	01-02 11-12	1940 1940	180 (112 m.p.h.)	180	5 420 (max. = 8 000)	23 000	114	4

The services worked by the E18 class locomotives (161 in total), and later with more reason, by the E19 class, were already reckoned in 1938/40 as the fastest — at least in Europe — for express working. The number of E19 locomotives in service at the end of 1940 was 4.

Fig. 82 shews a dimensioned sketch of a 1-C_0-1 locomotive, E04 series, mentioned above. In contrast to the E21 and E17 locomotives, the E04 as well as the E18 and E19, no longer have twin motors to each axle, but have a single superelevated motor per axle, as shewn in figs. 81 to 83. Fig. 83 shew the EKB 1000 motor of the E19 series, which gives nearly

([58]) See *Elektrische Bahnen*, Berlin, supplement 1941, « Das Elektrische Eisenbahnwesen der Gegenwart », pp. 120-122, also 1938, p. 283, and 1939, p. 92. — A very good illustration in colours of locomotive 19.01, which was the 5 000th delivered by AEG, may be found between pages 112 and 113 of the publication mentioned at the beginning of this note. — See also *Revue Générale des Chemins de fer*, Paris, No. 3, 1943, pp. 70-71.

Fig. 80. — Express locomotive, 1-D_6-1, series E.18, of the « Reichsbahn », hauling a motor set (see fig 108 of **Cde. indiv.**).

1 400 H.P. hourly rating (with single-phase current $16\,^2/_3$ cycles); also shewn in fig. 81 is a similar motor with overhead ventilator for the E18. On all these locomotives the gears are bilateral.

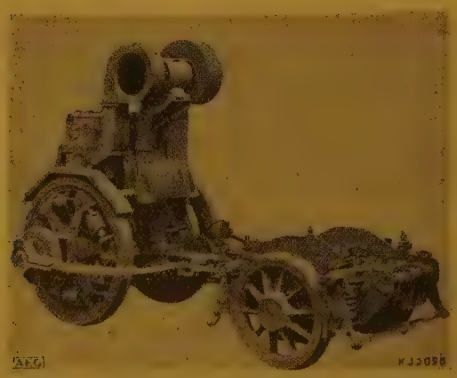


Fig. 81. — Carrying axle with driving axle and Krauss-Helmholtz leading truck, of the locomotive shewn in fig. 80, also E.19 series. Single overhead motor with ventilator (compare with figs. 82 and 83, and with figs 106 and 107 of **Cde. indiv.**).

Fig. 84 shews the parts of the AEG mechanism subject to wear, after 100 000 loco./km. (62 137 loco./miles) of heavy service. The replacement of these parts is not, therefore considered necessary before five years' service.

Because of the possible influence on the driving mechanism, as a result of heat generated when braking at high speeds, it is desirable to repeat something of what has already been said about braking [59]. As regards the operation of an E19 series locomotive, the weight is 114 tons, which is increased by 15 % for the rotating masses. Speed can scarcely be reduced by more than 1.5 m./sec² because otherwise 150 kgr./ton adhesion would be exceeded and the wheels would lock. To stop the locomotive alone, tra-

([59]) See p. 121 of 1941 supplement mentioned in note ([58]).

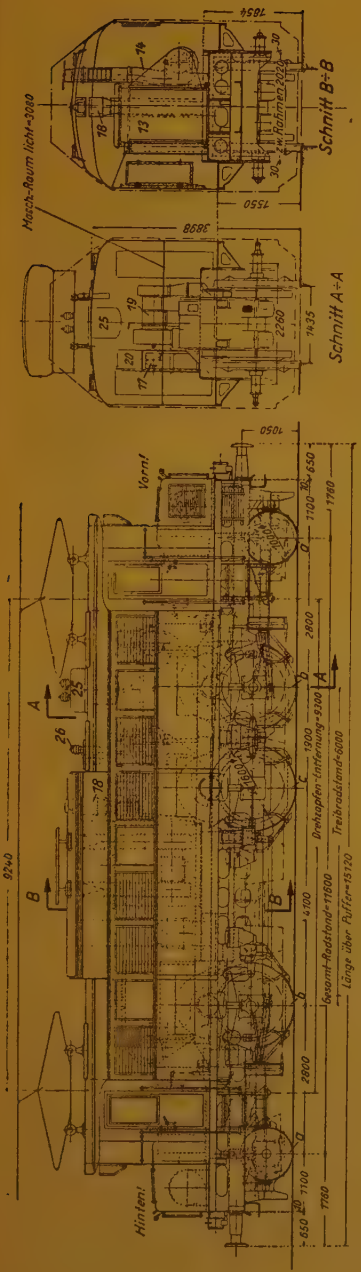


Fig. 82. — Locomotive, 1-C_0-1, series E.04, « Reichsbahn », in elevation and section, similar to E.17 series (see figs. 106-108 of **Cde. indiv.**).
Driving wheel-base = 6 m. (19′8″).
Total wheel-base = 11.6 m. (38′5/8″).
Distance between bissel (Krauss-Helmholtz) pivots = 9.3 m. (30′6 3/16″).
Schnitt = section.

D'après *Elektrische Bahnen*.

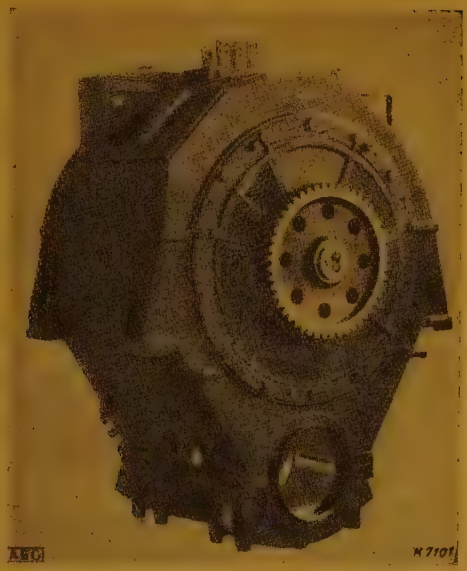


Fig. 83. — Overhead traction motor, 1 400 H.P., with pinion and shaft bearing of E.19, « Reichsbahn » locomotive (bilateral skew gears).

Fig. 84. — Wearing parts of AEG mechanism, after 100 000 loco-km. heavy service (see fig. 105 of **Cde. indiv.**, No. 2 and No. 4 couples and bearing plates resp.).

velling at 180 km./h. (112 m.p.h.), it is necessary to dissipate a force of 16.4 million kgr./m. equivalent to only 45 kW./h.

By reason of the signal interval, however, the whole train must be stopped in

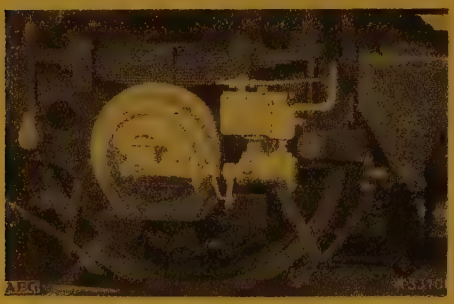


Fig. 85. — Centrifugal brake-application regulator, fitted to E.19 « Reichsbahn » locomotive.

about 33 sec., which requires for the locomotive alone — apart from air and running resistances — a braking effort of nearly 17 000 kgr. (37 478 lbs.) at 180 km./h. A force of 11 000 H.P. must therefore be dissipated during the first second. It is most difficult to find a material for the tyres to resist such stress. The driving wheels are braked up to 230 %, but when the speed has decreased to 55 km./h. (34 m.p.h.) a centrifugal regulator on the axle (fig. 85) reduces the brake effort to 80 %.

Austrian Railways (item 14 of Table A). — The Austrian Federal Railways' locomotives, 8 in number, with AEG-Kleinow mechanism were put into service between 1937 and 1942, the series being 1870, Nos. 1870.001 to 008, and the type 1-D_0-1 (fig. 86); they are similar to those of the « Reichsbahn », the driving mechanism and the Krauss-Helmholtz coupling of carrying axles to the neighbouring driving axles being exactly the same as on the « Reichsbahn » E18 series.

The mechanical details are very similar (see dimensions in fig. 86). The axle-loads are 19.7 t. for the driving axles and 15.6 t. for the carrying axles; the tare being 110 tons. The hourly rating is 4 900 H.P. at a speed of 98 km./h. (61 m.

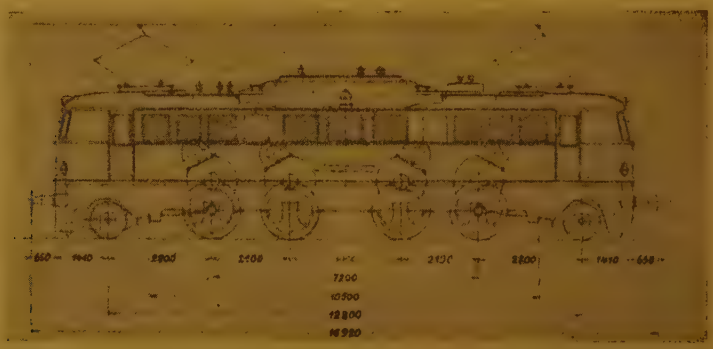


Fig. 86. — Dimensioned sketch of 1-D_0-1 locomotive, series 1870, Austrian State Railways. (See figs. 80 to 83.)

Rigid wheelbase = 3 000 mm. (9′10$^1/_8$″). Length between pivots = 10 500 mm. (34′5$^1/_{10}$″).
Driving wheelbase = 7 200 mm. (23′7$^1/_2$″). Total wheelbase = 12 800 mm. (42′).

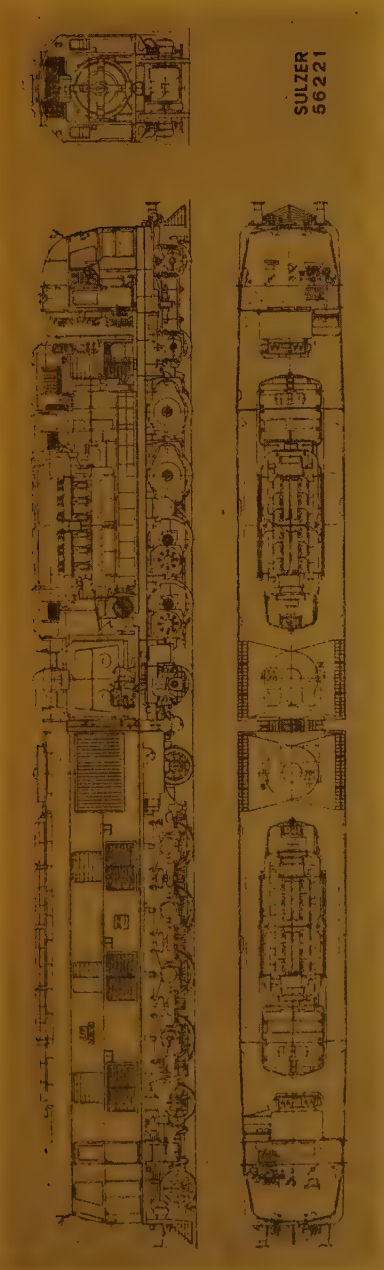


Fig. 87. — Diesel electric (double) locomotive of the Rumanian State Railways, in elevation, plan and cross-section.
Distance between driving wheel centres on each half-locomotive = 1 800 mm. (5'10⁷/₈").
Total wheelbase = 26 m. (85'3⁵/₈"); per half-locomotive = 11 850 mm. (38'10½").
Length over buffers = 29.3 m. (96'1⁹/₁₆").

p.h.), the maximum operating speed being 130 km./h. (81 m.p.h.).

Rumania, CFR (item 15 of Table A). — Another interesting use of the AEG mechanism, this time with the traction motors placed alongside the axle at the same height (axle and motor axes parallel and in the same horizontal plane) is on the 4 400 H.P. Diesel-electric locomotive, type 2-D_0-1+1-D_0-2, series DE2.241, No. 001-002, of the Rumanian Railways « Caile Ferate Române », CFR. This locomotive, built by Sulzer Bros., Winterthur, Switzerland, in collaboration with the Henschel Locomotive Works, Kassel, for mechanical parts, and Brown-Boveri, Baden (Switzerland), for the electrical equipment, was put into service in the autumn of 1938 ([60]), on the mountain line across the Carpathians, Câmpina-Predeal-Brasov (or Bucharest-Brasov = 170 km.) which has gradients between 13 and 25 ‰ and numerous curves.

Figs. 87 to 90 shew respectively an elevation and a plan of the locomotive; the locomotive in service; a driving axle com-

([60]) See :

Revue Technique Sulzer, Winterthur, No. 3, 1938.

Bulletin CFF, Berne, May, 1938, p. 75.

Engineer, London, 20th May, 1938, p. 571.

Railway Gazette, London, June, 1938, p. 1134.

Oil Engine, June, 1938, p. 40.

Organ für die Fortschritte des Eisenbahnwesens, Berlin, 15th June, 1938, p. 233.

Glasers Annalen, Berlin, 1st July, 1938, p. 183.

Engineering, London, 22nd July, 1938, p. 100.

Revue Brown-Boveri, Baden, Switzerland, October, 1938.

Revue Polytechnique Suisse, SBZ, Zurich, 19th November, 1938, p. 252.

Ferrocariles y Tranvias, Madrid, April, 1940, p. 114.

Fig. 88. — Diesel-electric locomotive, 4 400 H.P., 100 km./h. (62 m.p.h.), for fast service on the Campina-Brasov line, Rumanian State Railways, with international train, at Predeal Station (locomotive shewn in fig. 87).

Fig. 89. — Complete driving axle of locomotive shewn in figs. 87 and 88, with motor in the axle plane, supported by hollow shaft and underframe (left). Frame outside wheels (see fig. 90) and isothermos boxes.

plete and a lateral view of the axle in service. The diameter of the driving wheels in this case is only 1 350 mm. (4′5 1/8″), the rigid wheelbase (four driving axles) 5.4 m. (17′8¾″), the weight in running order is 230 tons and the maximum driving axle load is 19 tons.

Photo Hug.

Fig. 90. — Axle (shewn in fig. 89) in position under locomotive (figs. 87 and 88).

The maximum speed is 100 km./h. (62 m.p.h.) and the maximum starting tractive effort is 37 tons. The two half-locomotives are symmetrical, the driving mechanism bilateral (unilateral gears) with hollow shaft, the underframe being outside the axles. The gauge is normal 1 435 mm. (4′8½″).

Sweden, S.J. (item 16 of Table A.) — The recent Swedish applications of the Kleinow-Westinghouse mechanism have developed as follows : after the report drawn up by the Commission charged in 1938 with the study of new types of locomotives, the Royal Swedish State Railways (SJ) decided on the introduction of two types of electric locomotives (to be standardised after trials) with individual flexible drive and hollow shaft, viz :

a) for express and passenger trains, a type F (1-D_0-1) of 3 500 H.P., max. speed 135 km./h. (84 m.p.h.), max. tractive effort 18 tons, diameter of driving wheels 1 530 mm. (4′11 1/16″) (figs. 91 and 92) ([61]).

b) for good trains, a type M, (C_0+C_0) of 3 600 H.P., maximum speed 80 km./h.

([61]) See *Railway Gazette*, London, 2nd February and 2nd March, 1945, pp. 109-110 and 206-207 (4 figs., 3 tables). The notes on Engine F.602, Table III, p. 206, are incorrect (wrong position of the pins over the driving boxes).

(50 m.p.h.), maximum tractive effort 30 tons, wheel diameter 1 100 mm. (3′ $7^{5}/_{16}$″) (fig. 93).

Of the three trial locomotives, type F,

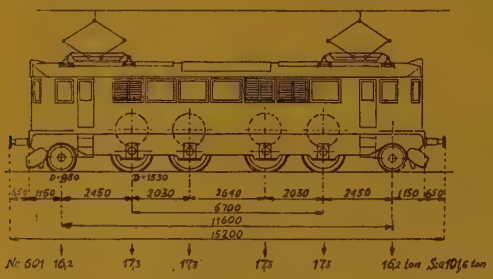


Fig. 91. — Dimensioned sketch of 1-D_0-1 locomotive, type F, for express service, Swedish (SJ) Railways. (See fig. 92.)

put into service in 1942, numbered 601 to 603, two were fitted with the new Secheron mechanism (Meyfarth-Secheron system, driving rods acting on different parts of the cased coil spring) which will be described later, and one with AEG-Kleinow mechanism ([62]). These three locomotives have been tried on services up to 135 km./h. (84 m.p.h.) in express service between Stockholm and Malmö.

In view of the good results obtained with the AEG mechanism, the SJ ordered 21 F type, 1-D_0-1, locomotives, of which 12 — Nos. 621 to 632 — were supplied in 1945/46, and the remaining 9 are to be supplied in 1948. Fig. 92 shews loco-

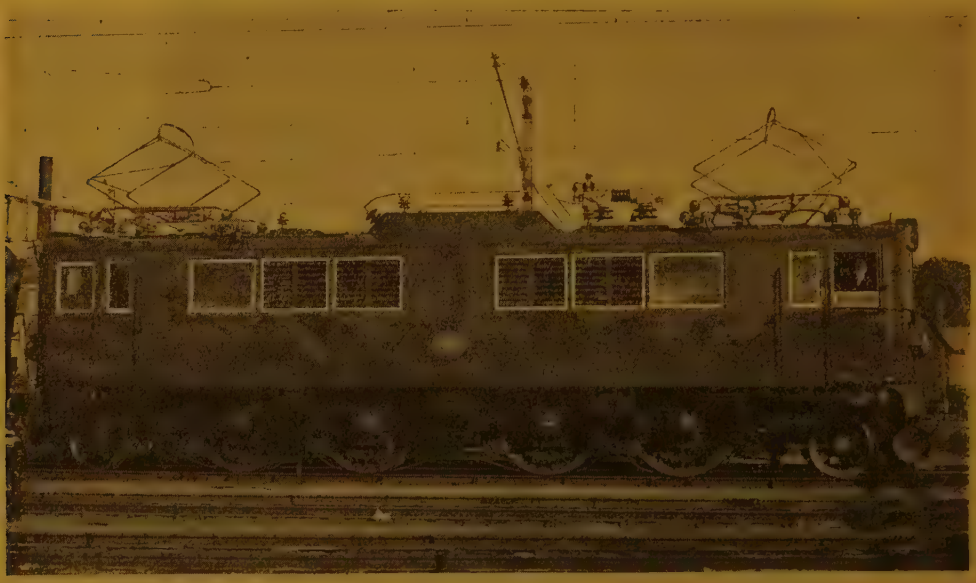


Fig. 92. — Locomotive No. 620, 1-D_0-1, with bissel trucks, type F, same series as fig. 91, Swedish (SJ) Railways), fitted with Westinghouse-Kleinow mechanism.

([62]) The information in the *Railway Gazette*, note ([61]), on the use of ASEA (Allmänna Svenska Elektr. Aktiebolaget, Västerås) on one of these three engines is incorrect; this mechanism was not used, but similar arrangements tried have not been satisfactory (see, for example, figs. 169 and 170 of **Cde. indiv.**).

motive No. 629. Apart from heavy wear on the axle bearings, the SJ has so far been quite satisfied, but the length of service has been too short to allow definite judgment.

These Swedish F-class locomotives have bissel trucks at each end, as on the

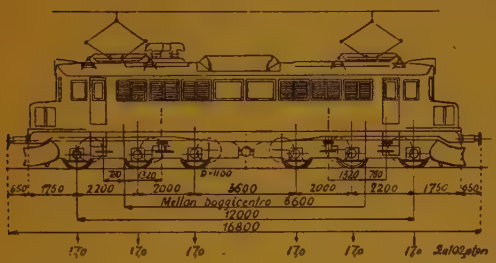


Fig. 93. — Dimensioned sketch of C_0+C_0 locomotive, type M, for Swedish (SJ) Railways.

trial locomotive No. 603. The two trial locomotives Nos. 601 and 602 were first fitted with Krauss coupling of carrying and driving axles (see figs. 106 and 107 of Cde. indiv.) ([63]), but were subsequently converted to conform with No. 603. For further details regarding these locomotives, see the article mentioned in note ([61]).

The reasons which led the Swedish SJ to prefer the Bissel truck to the Krauss were : the Bissel truck is lighter than the Krauss and the latter does not shew any operating advantages by comparison with the former. These three locomotives, 601 to 603, are fitted with inclined-plane wedges for the axial return of the carrying axles, with two-point suspension.

The same device has been fitted on F-type locomotives constructed since.

([63]) See *Elektrische Bahnen*, Berlin-Munich, June, 1936, pp. 131-132.

Fig. 94. — Express locomotive, 3-D_0-3 (6-8-6), S.2 class, steam-turbine, No. 6200, 1945, Pennsylvania RR. (see figs. 95-97), 6 500 H.P. at 150 km./h. (93 m.p.h.), maximum speed 180 km./h. (112 m.p.h.), weight in running order 450 tons (with tender).

(Cliché : *Economie et Technique des Transports.*)

Fig. 95. — Same locomotive as fig. 94, seen from the opposite side, with train in service. Flexible transmission to the two central driving axles.

Fig. 96. — Group comprising transmission to two central axles of locomotive, figs. 94 and 95.

The M-type locomotives (see *b*) above, fitted with the Meyfarth-Secheron mechanism mentioned above, will be described later when dealing with this more recent mechanism.

Steam turbine locomotives.

An interesting application of the quill cup drive to a steam turbine locomotive was carried out in 1944 on the 3-D-3 locomotive, S-2 class, No. 6200, of the Pennsylvania RR. This does not, however, concern individual axle drive, but refers to quill cup drive with very robust couples, divided along a vertical plane (perpendicular to the axles and, as already stated, similar to the original) transmitting — through gears — the couple of two turbines to two central driving axles, the four driving axles being *rod-coupled*.

Figs. 94 to 97 shew the arrangement and the locomotive, which develops more than 6 500 H.P. at a speed of

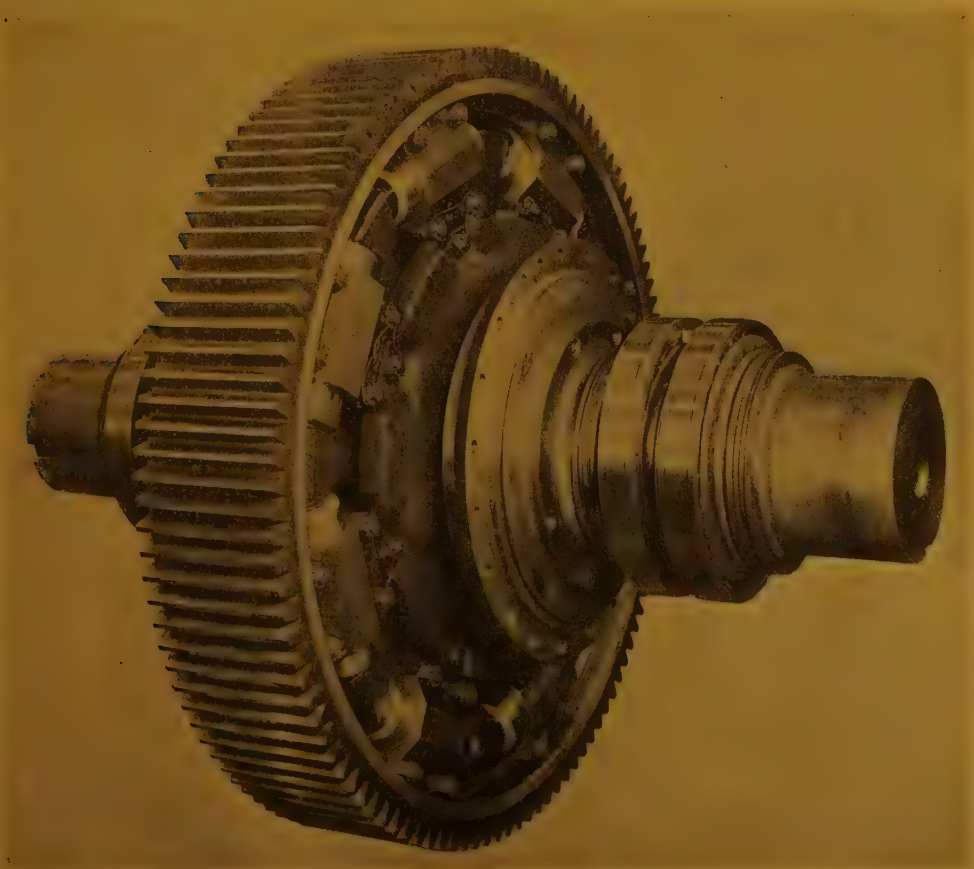


Fig. 97. — Main gear wheel of group, fig. 96, with flexible transmission, cup drive, from turbine. Part of group shewn in fig. 96.

105 km./h. (65 m.p.h.) (max. speed 184 km./h. [114 m.p.h.]) (64). The two turbines are arranged as shewn in fig. 96.

Whilst dealing with turbine locomotives, the French uses of quill cup drive may be mentioned in reference to the locomotive under item 9 of Table A. This locomotive (65), which was blown

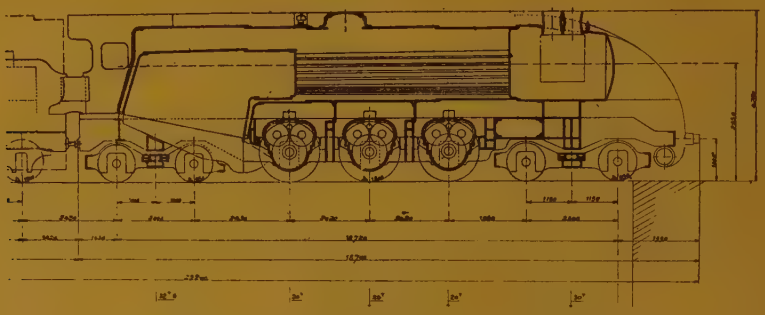


Fig. 98. — Steam turbine locomotive, type 2-C_0-2, with individual axle drive, quill cup, French National Railways, SNCF., 1939.

Fig. 99. — Same locomotive as fig. 98 (No. 232-Q.1) without streamlined casing.

(64) See the following reviews :

Westinghouse Engineer, Pittsburgh, March, 1945, pp. 34-40, 7 figs., 11 diagrams and tables.

Railway Gazette, 31st May, 1946.

Revue Générale des Chemins de fer, Paris, March, 1947, p. 106.

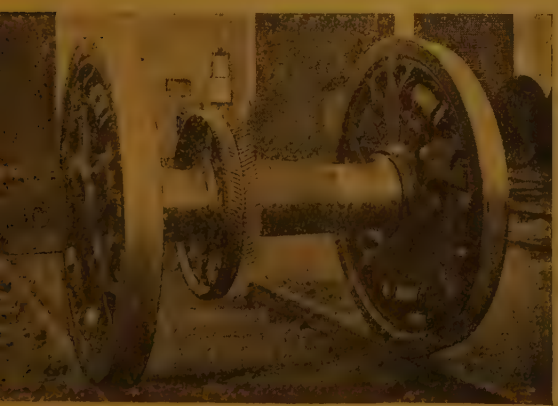
Economie et Technique des Transports, Lucerne, No. 70 (International Railway Congress), pp. 57-58, 2 figs.

N.B. — The three locomotives of the 500 series, type 2-D_0+2-D_0-2, 1946/47, of the Chesapeake and Ohio (Atlantic City) are steam turbines (coal) with electric transmission (individual operation, nose-suspended motors). Power 5 100 (6 000) H.P.; total wheelbase 42.7 m. (140'1"). Twin generators DC. See *Westinghouse Engineer*, September, 1947.

(65) See *Revue Générale des Chemins de fer*, Paris, January-February, 1941, and March-April, 1942, pp. 152-153. — A further steam turbine was built with Universal (SLM) mechanism, and this will be discussed in Chapter V.

up by the Germans in the retreat from France in 1944, is shewn in figs. 98 and 99. In contrast to the PRR locomotive, individual axle drive was provided. Figs. 100 and 101 shew a driving axle complete, in end and side view respectively.

Fig. 100. — Driving axle, with five couples, monobloc cup drive, of *steam* turbine locomotive, figs. 98 and 99. Note the gear wheel on the hollow shaft (see fig 101).

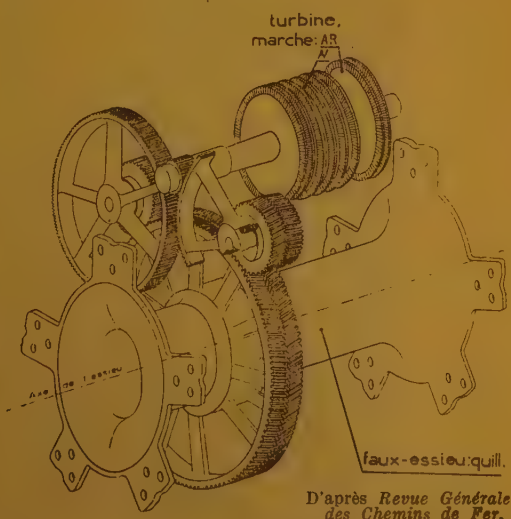


g. 101. — Same driving axle as fig. 100 with gear wheel for transmitting drive of turbines.

The transmission mechanism (gears) of each of the three driving axles with its *forwards* and *reverse* turbine is shewn in figs. 102 and 103. The power of this locomotive is about 3 000 H.P. at rail; there is no condensation. The speed of the turbines is 10 000 r.p.m., so that with the axles revolving at 500 r.p.m. the reduction ratio is 20.

We now come to the SNCF (French) electric locomotives fitted with the Westinghouse quill cup drive (β of Table A) and AEG-Kleinow (γ of same Table, item 13).

The P-O, Orleans, system put into service in 1934 a trial locomotive, E.704 (item 7 of Table A), type 2-D_0-2 (fig. 104). This locomotive gives an hourly rating at rail of 4 950 H.P. at a speed



D'après *Revue Générale des Chemins de Fer.*

Fig. 102. — Sketch of arrangement of turbine with driving axle, gears and hollow shaft, of locomotive in figs. 98 to 103.

faux essieu quill = quill shaft,
axe de l'essieu = axle centre line.

of 96.5 km./h. (60 m.p.h.). The maximum power recorded on the contact line during trials was 6 000 H.P. at 90 km./h. (56 m.p.h.) at the average line tension of 1 350 V. The maximum speed reached with a drawbar load of 176 tons (4 vehicles) during trials at the beginning of 1939 was 180 km./h. (112

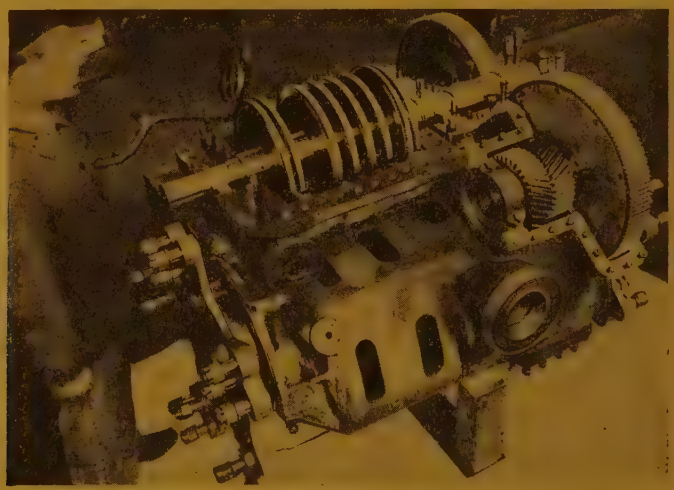


Fig. 103. — Photograph of mechanism shewn in fig. 102. The V-shaped pinion teeth can be seen engaging the gear wheel, fig. 101 (see also fig. 98).

Fig. 104. — Express locomotive, E.704, Paris-Orleans. Quill cup drive with monobloc couples. 5 000 H.P. Max. speed in service 130 (150) km./h. (81 [93] m.p.h.). Tare, 136 tons.

m.p.h.). An average speed of 170 km./h. (106 m.p.h.) was maintained over 20 km. (12 miles) between Blois and St.-Pierre-des-Corps ([66]), with a total train resistance (including locomotive) of 11.2 kgr./ton. The total weight of this locomotive is 136 tons, 86.3 tons for the mechanical parts and 49.3 tons electrical equipment. The mechanical part was constructed by the Schneider Works, Le Creusot, and the electrical equipment by the « Société Le Matériel Electrique S-W », in collaboration with Westinghouse Electric and Manufacturing Co.

Figs. 105 and 106 shew respectively a complete driving axle of this locomotive No. 704, with the twin motor mounted on the hollow shaft, and a pair of driv-

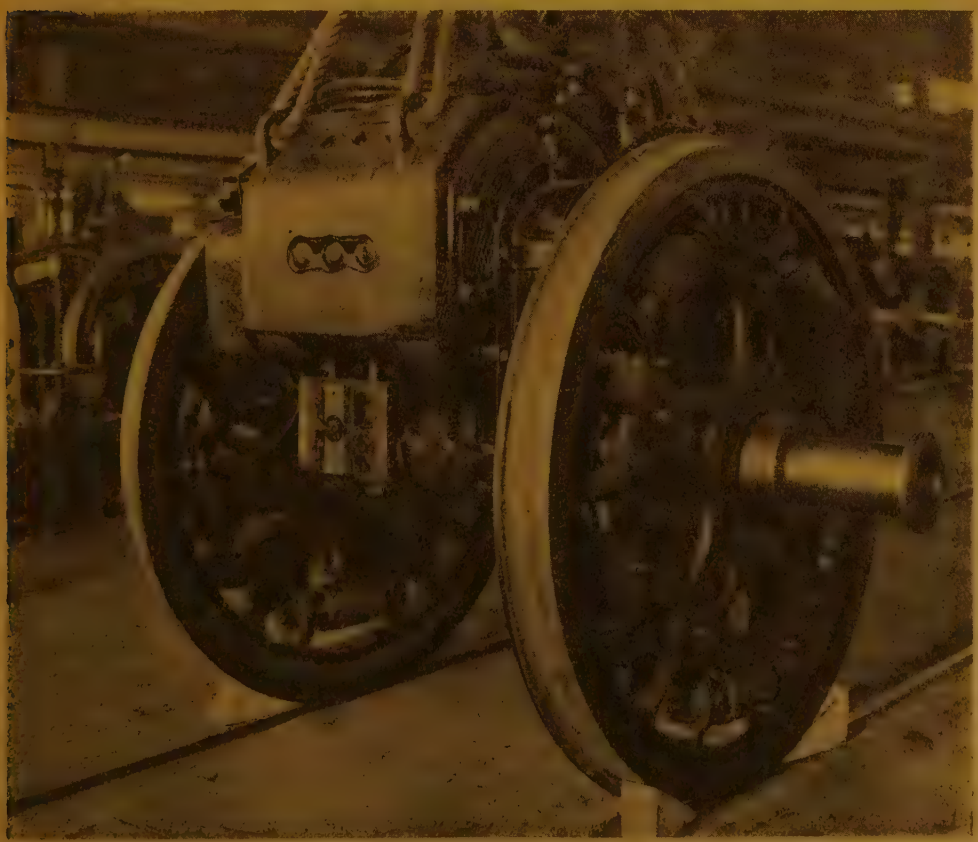


Fig. 105. — Driving axle with twin motor unit mounted on hollow shaft, locomotive in fig. 104.

([66]) See *Railway Gazette*, Electric Traction Supplement, p. 32, 31st March, 1939.

ing wheels and axle with hollow shaft and unilateral gear, shewing clearly the special form of the wheel centre. Monobloc couples can be seen (see text to right of fig. 68) and an odd number is used (5 only). With regard to the components of the flexible transmission, see fig. 71.

By the end of 1943, this locomotive had completed a mileage of 430 000 km. (267 190 miles).

In view of the good results obtained, the P-O/MIDI (meanwhile forming part of the Orleans-Midi and now SNCF-SW) has put into service since 1937, 16 further locomotives of the same type, Nos. E.705 to 720 (item 8 of Table A) similar to that in fig. 104 but streamlined (see figs. 13 and 14), the mileage of which now averages about 1 000 000 km. (621 372 miles) each ([67]).

Lubrication of the couple-heads and bearing plates is by Crater Compound grease through grease cups on the wheel

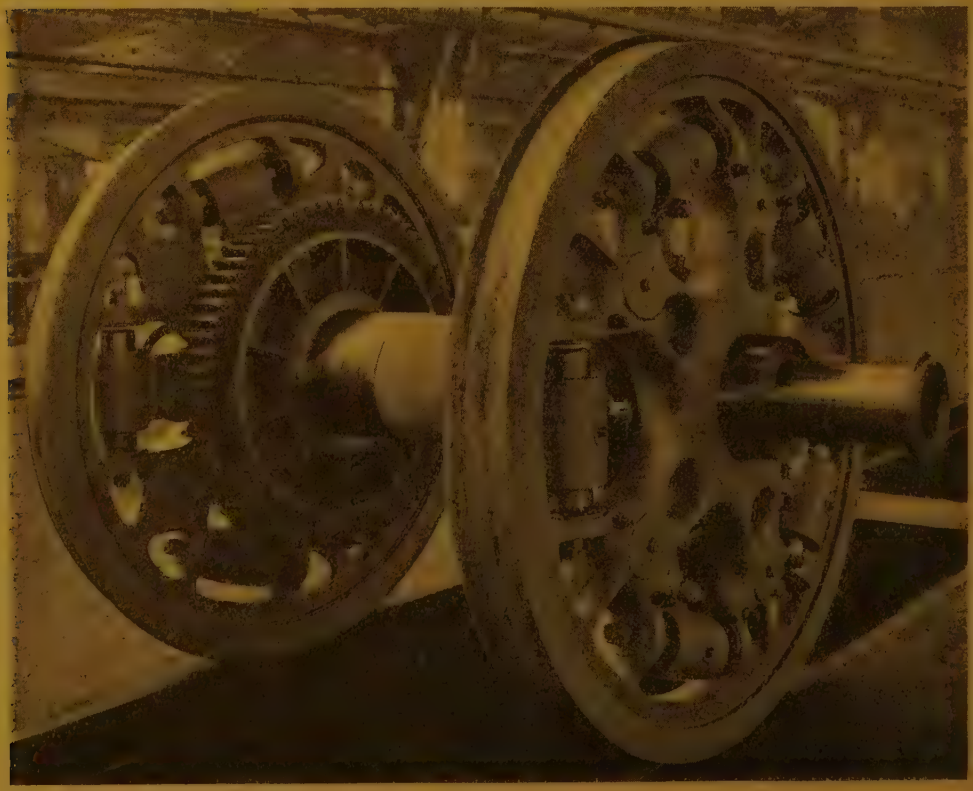


Fig. 106. — Pair of driving wheels with hollow shaft and gear wheel, locomotive in figs. 104 and 105 (5 couples only).

([67]) Two locomotives of this series were destroyed by air attack in 1944.

centre of the driving wheels (see fig. 106). General repairs are carried out after 200 000 locomotive/km. (124 274 miles).

To conclude the uses of quill cup drive (steel coil springs) it only remains to deal with item 13 of Table A.

Fig. 107. — Express locomotive No. 4823, P.-O.—Midi. Quill cup drive (AEG) with divided couples, 3 700 H.P. Max speed in service 130 km./h. (81 m.p.h.).

This concerns 18 2-D_0-2, Nos. 4807-4824, locomotives of the SNCF-SW, put into service in 1935/37. The hourly rating on rail is 3 700 H.P. with 1 500 V. line voltage and a maximum operating speed of 130 km./h. (81 m.p.h.).

The flexible transmission, AEG-Kleinow type, is similar to the « Reichsbahn » uses (see figs. 79-84). Locomotives 4807-4822 were built by the « Constructions Electriques de France » CEF, for the mechanical parts and Als-Thom for the electrical equipment. The two locomotives 4823-4 were built by AEG, Berlin, but to Als-Thom design and are identical to the others.

Fig. 107 shews one of the locomotives. The flexible transmission has an even number of couples (= 6), divided vertically (see figs 102-105 of Cde. indiv., also fig. 75).

(To be continued.)

[656 .254 (.44)]

The use of radio communication by the French National Railways,

by M. WALTER,

Ingénieur en Chef au Service Technique des Installations Fixes.
Chef de la Division des Installations de Sécurité, de Télécommunications et de Caténaires à la S. N. C. F.

(Revue Générale des Chemins de fer, January 1947.)

I. — Use of wireless by the French railways prior to 1940.

Before the events of June 1940 — which for fifty months put a complete stop to all open activity in the matter — the French railways had laid down a considerable variety of equipment and conducted a number of trials with radio-electric communication. It will serve if we mention among others the following:

1. Communication between a fixed point and a locomotive or train in motion. — The Nord Company in 1932 made trials on its Paris-Amiens section of communication between a fixed station at Creil and a train in motion, with the object of allowing passengers to exchange telephone conversations with the interurban network of the Post and Telegraph Department. These trials were given up for economic reasons and especially on account of the difficulty of settling the rates and collecting payment for the telephone calls.

The Bourget marshalling yard was equipped in 1933 with two-way inductive telephone communication using currents at voice frequency. This installation remained in service until it became unserviceable during the war. In 1936, at the La Chapelle marshalling yard, trials were made with two-way short wave apparatus, but without satisfactory results.

On the State Railways a two-way communication using a wave-length of 30 to 40 m. (33 to 44 yards) was tried in 1932 in the Vernouillet marshalling yard, without success. In the same year, at Trappes, trials using a wave-length of 6 to 7 m. (6.56 to 7.65 yards) led likewise to no result, as did those carried out in 1933 at the Le Mans yard. On the other hand, in the Port of Rouen in 1933, a two-way communication was set up between a fixed station and two engines which worked correctly, although somewhat irregularly as a consequence of defects attributable to the power supply (the wave length was 6.5 m. [7.10 yards]).

The Paris-Orleans Company began in 1930 making trials with short wave transmission; in 1932 communication was established, first at Austerlitz station, then a Juvisy, but these trials led to no permanent service being brought into use.

Summing up we may say that prior to the war a number of trials had been carried out, but none using free waves resulted in an installation working regularly in a satisfactory manner.

2. Communication between the engine and the last vehicle in a train. — Trials were made on the Northern line in 1931, but led to no useful result.

3. Communication between two fixed stations. — The Military Telegraph Service, working in conjunction with the National Railways, designed and fitted up in 1939 several transmitter-receiver stations using free waves or beam transmission, intended to provide, should it

be necessary, communication between centres on the system where military sub-commissions were stationed. These stations were either destroyed in 1940 or removed into non-occupied territory.

4. Coastal stations for communicating with the mail steamer services. — The Calais Marine station operated as a telegraph transmitter on a 700 m. (765.53 yards) wave length.

That at Dieppe Jetty worked in a similar manner on four wave lengths (600 m. [656.16 yards] for emergency calls for assistance, 700 m. for communicating with vessels and for calling Newhaven, 220 m. [240.59 yards] for the trawler traffic and 142 m. [155.29 yards] for exchanging messages with Newhaven).

II. — Designs and installations effected by the French National Railways since the liberation.

1. *Communicating channels for management purposes.* — At the commencement of September 1944, it was clear that one of the most urgent tasks facing the French National Railways was that of re-establishing rapidly its telecommunication circuits, which had been very badly damaged. Its system of communicating channels allocated to management purposes in particular had been destroyed at numerous places and it was a matter of special urgency to get them again into working order.

The lack of materials and labour meant that there would be considerable delay before the open line wire circuits would be able to function again. As regards the long distance underground cables belonging to the Post and Telecommunications Department, they had been in many cases rendered useless for the time being by the destruction of the repeater stations. Recourse to wireless communication was therefore the quickest and most satisfactory way to set up provisional channels to those offices and other places not connected by open line or underground cable circuits.

It was under these circumstances that, in the early days of the liberation, the French National Railways obtained from the Advisory Committee on Imperial Telecommunications the release on its account of some transmitter-receiver assemblies made by the Thomson-Houston Company and incorporating all the latest technical improvements. The Allied Command gave permission to the French National Railways to set up a small number of radio-telegraphic channels, using only frequencies of 3 728, 3 408 and 5 995 Kc./s., on the condition that the power in the aerial was not to exceed 300 watts.

To keep within the restrictions so imposed the French National Railways which at the outset had had in mind setting up a network connecting the five Regional Department Offices at Paris with the corresponding centres in the provinces and the linking up of these latter with one another, limited its programme to the Western and South-Eastern regions, where the need to re-establish quickly long distance communication was particularly felt and where the reconditioning of the damaged lines involved the longest amount of delay.

The establishment of these channels of communication was undertaken at once and from September 22th 1944, the Western Region had such at its disposal, enabling messages to be exchanged between the three centres of Paris, Le Mans and Caen, to which Rennes was added from November 3rd. In the case of certain of these towns, notably Caen, this channel was for a long time the only means of communication with Paris.

The restoration, during January 1945, of direct communication by wire between Paris, Le Mans and Rennes allowed of the equipment at the two last named places being transferred to Argentan

and Granville, which up to then had been without any means of communication whatever.

On the South-Eastern Region the Paris-Lyons-Marseilles channel was set up on November 10th 1944, and then in due course the one connecting Paris, Dijon and Lyons.

While the wireless channels in the South-Western Region were dispensed with stage by stage as they were replaced by open line or cabled circuits, those between Paris, Dijon, Lyons and Marseilles on the contrary were retained and have continued to prove extremely useful. In fact, the French National Railways channels and the Postal Department cables cannot cope with the whole of the traffic between these large centres and the support furnished by the radio-telegraphic channels is very valuable indeed to the railways. In addition, the line wire and cable circuits have several times suffered interruption, while the wireless channel remained unaffected.

The four-stage H.F. transmitters used, Thomson-Houston Company's type 1040, have an aerial wattage of 275. They work over the whole band of frequencies, between 23 150 kc./s. and 2 500 kc./s. in eight sections, largely overlapping.

The method of working is modulated telegraphy. The apparatus has four levels, the stability of the frequency being ensured by a master-oscillator.

Up to the termination of hostilities messages partaking of a military character were sent with the aid of a numeral code supplied to the French National Railways by the High Command of the Allied Expeditionary Forces.

2. *Channels serving marshalling yards or lines alongside ports and harbours.* — The chief problem for the French National Railways in this respect consisted in providing its marshalling yards as they were gradually restored to working order with wireless equipment incorporating the latest advances made during the war.

Several trials were carried out in yards in the Paris suburban area with American military equipment both for establishing communication between the hump cabin and the marshalling locomotive, as well as between the locomotive (or some fixed point) and an employee moving about in the yard. It was seen to be necessary however to develop a design of apparatus which could be supplied easily in France, especially as regards valves and power supply. French manufacturers were accordingly asked to go into the question and make proposals.

At the present moment, several manufacturers are interesting themselves in the matter and are managing to produce designs intended to meet the very special requirements called for in such equipment.

Trials were made on steam, diesel, and electric locomotives. The equipments used in some cases frequency modulation, in others amplitude modulation. The frequencies in one instance between 150 and 180 Mc./s., in the other between 30 and 60 Mc./s., are more or less equal to the intervals among which the frequency allocation reserved to the French National Railways may be considered to come. The tests covered both one way and two way communication, except, be it noted, in the case of the 150-180 Mc./s. range, where one-way communication only was tried.

The absence of disturbing stray currents was noted during the tests both as regards the electric traction equipment or the apparatus on the engines, and equally with amplitude or frequency modulation. Hearing qualities proved satisfactory, without vehicles or other objects forming barriers; but certain levels of power proved necessary, especially with apparatus fitted on diesel engines.

We shall describe here only the equipment at the Trappes marshalling yard, the only one regularly in service at the end of 1946, and carried out practically on definitive lines.

In this case it was a question of connecting the hump cabin to the marshalling locomotives on a one-way channel, this arrangement being preferred by those responsible for using the apparatus in this case.

The installation was carried out by Mr. MAGONDEAUX in association with the French National Railways. It has been working since September and comprises the following parts, of which the technical details and general arrangement are covered by the figures (diagrams and photographs) given below, namely :

— *at the hump cabin location :*

One radio-telephonic transmitter, 25 watts, made up of :

— a modulating amplifier with a piezo-electric microphone (Fig. 1).

— a transmitting oscillator, using a lineal circuit and sending out waves from a tubular aerial placed at the top of a lighting standard 30 m. (98′5¹/₈″) high, near the hump cabin (Fig. 2).

The installation takes it current from the local area power supply.

— *on the marshalling locomotive :*

— a low frequency amplifier with electro-dynamic type loud speaker, inside

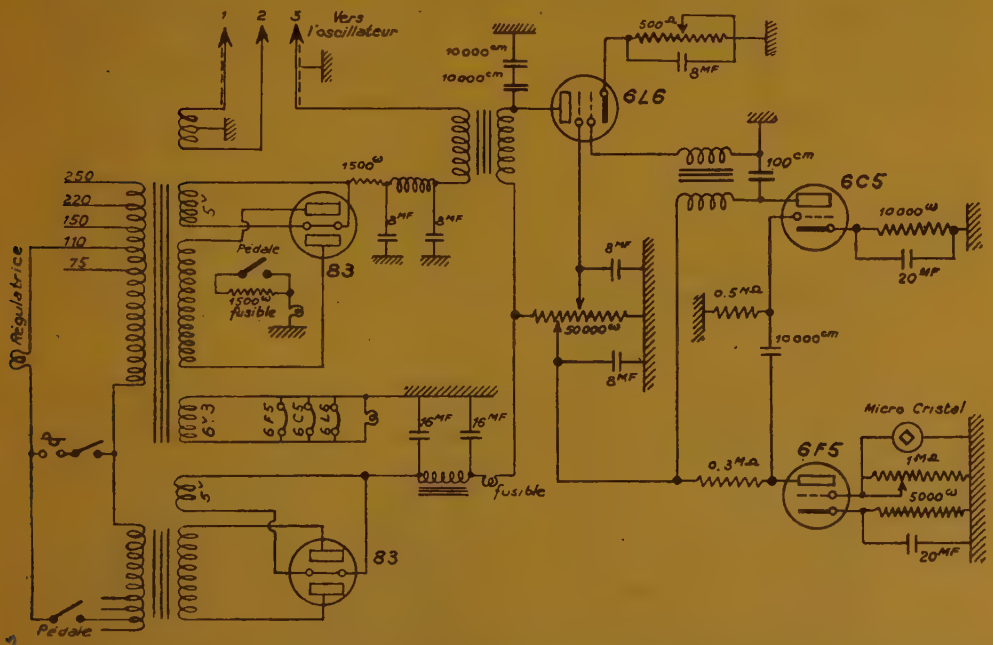


Fig. 1. — Fixed French National Railways' transmitter 166 MC. (Feed. — Modulation [Magondeaux E.846].)

Explanation of French terms :

Pédale = foot contact. — Vers l'oscillateur = to the oscillator. — Fusible = fuse. — Micro-cristal = crystal microphone. — Régulatrice = adjuster.

the driver's cab, fixed to the roof on the lefthand side. A second loud-speaker similarly fixed, is placed on the fireman's side, on the right.

— an oscillatory receiver, super re-active type, with receiving aerial (half-wave) fixed ouside the locomotive level with the cab roof (Fig. 3).

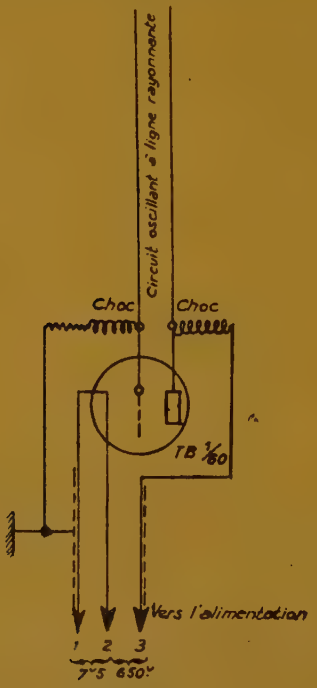


Fig. 2. — Oscillator for E 846 transmitter.

Explanation of French terms:

Choc = choke. — Vers l'alimentation = to feed. — Circuit oscillant à ligne rayonnante = oscillatory circuit leading to radiating line.

A 24-volt accumulator battery provides the feed for a converter set which provides the necessary H.T. current. The battery is trickle-charged by a 600-watt turbo-generator set.

The accumulators, converter and turbo-generator sets are mounted on a base plate on the locomotive forward of the cab.

The setting in action of the equipment and its use for communication are very simply effected as follows :

a) operations to be carried out *by the shunter at the hump :*

— turn the switch which supplies power to the transmitter;

— after an interval of 30 seconds (the time required to allow the valves heated indirectly to warm up) the apparatus is ready to work;

— the person in charge can then send the messages intended for the locomotive driver by speaking in front of the microphone and keeping a foot pedal depressed while so doing.

b) operations to be carried out *by the driver :*

On taking up work with the locomotive he must :

— press the button which puts the receiver in action;

— operate the steam valve of the turbo-generator.

The receiver starting button also permits of the driver regulating the power of the loud-speakers if he so desires.

The frequency used of 166 megacycles (1.80 m. [5'10"/8"] wave length) is set and adjusted once for all, and those using the equipment have no other operation to effect beyond those mentioned above.

The radio-telephonic apparatus, properly so called, is of very small dimensions and causes no inconvenience whatever to the driver or fireman in the carrying out of their duties. It is shielded from the effects of dust, dripping water or steam (figs. 4, 5 and 6).

The range obtained is several kilometres and amply sufficient for requirements, without, however, giving rise to disturbances in the neighbourhood.

The equipment at Trappes involves three shunting locomotives. In addition a reserve set of apparatus is available for rapid fixing to any engine at any moment required.

During the course of 1947 several marshalling yards, as they were restored to working order were provided in turn with radio-telephonic installations, either

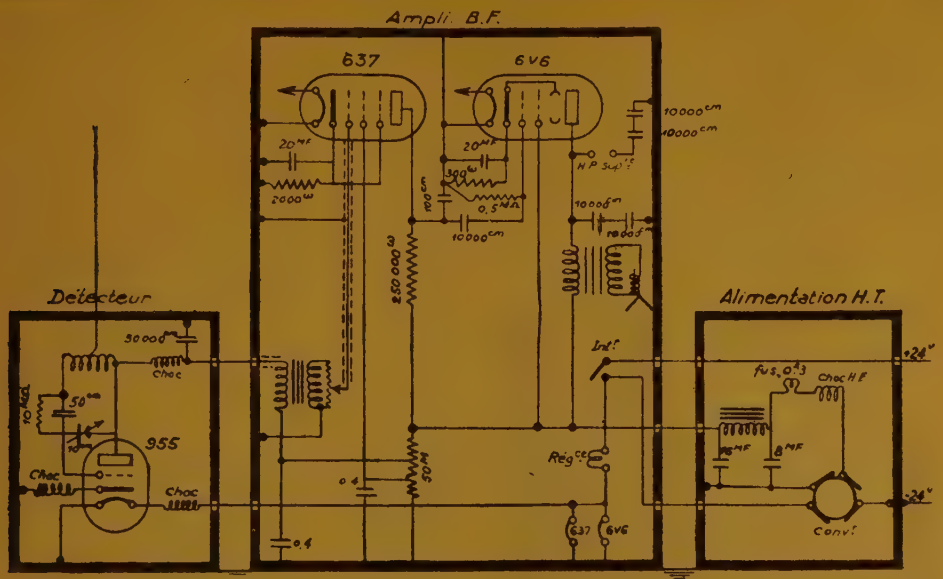


Fig. 3. — Receiving assembly 166 MC. French National Railways' type, for engine (Magondeaux R 846).

Explanation of French terms:

Intr = cut out. — Fus = fuse. — Choc = choke. — Détecteur = detector. — Alimentation H.T. = high tension feed. — Convr. = converter. — Reg. = adjuster.

Fig. 4. — View showing arrangement of aerial on engine.

one-way or two-way. In addition, the equipping of dock and harbour lines is carried out, using apparatus having a range greater than that of the marshalling yard installations (up to some 10 km. [6 miles]).

Another system of this kind has been tried at Trappes, in the form of portable sets of equipment for the use of the shunters. Constructed by the Jardillier Works (under Magondeaux licence) for use at air landing grounds and take off points, it comprises :

— a transmitter-receiver assembly, allowing of alternate two way conversations and made up of :

— a transmitter-receiver unit of small size (117 mm. × 88 mm. × 66 mm. [$4^{10}/_{16}$" × $3^{15}/_{32}$" × $2^{19}/_{32}$"]) working on 166 Mc./s. and 1.80 m. wave length.

— a microphone and a head-piece with two receivers plug and cord connected to the unit;

— a dipole type aerial formed by two parallel conductors 0.50 m. (1'7$^{11}/_{16}$") long and 4 mm. ($^{5}/_{32}$") diameter, mounted vertically on the unit;

— a container holding a small 6-volt accumulator providing the current for heating the valves and a 100-volt dry battery for the high tension feed.

Fig. 5. — Receiving loud-speaker fixed in cab.

The total weight is 1.700 kgr. (3.74 lbs.).

The complete assembly can be carried by an employee walking about the yard.

This arrangement allows of two-way conversations between the employee out on the ground and another set of apparatus, which may be on a locomotive, or at some fixed point.

Tests have shown that within a radius up to 2 km. (2 187 yards) hearing is good and working satisfactory. This distance is more than sufficient for the employees dealing with the marking and attaching of wagons, but it would be an advantage to increase it to 4 km. (4 374 yards) or so for the rolling stock inspecting staff. Trials with this object are being carried out at Trappes.

Summing up, it may be said that on the French railways we are far from having applied wireless communication on the scale seen in certain other countries, especially the United States, but it is to be observed that French manufacturers had to begin at the beginning, or little short of it, at the moment of the liberation, and that what has been accomplished since then has involved the overcoming of considerable difficulties of all kinds, while the problems facing the French lines and the possibilities of applying wireless there are noticeably different from those met with in America. For instance, communication between the head and tail of a train offers less interest to us than it does to the Americans, from the fact that the operating conditions are not the same, and notably from the circumstance that our shunting movements effected in the course of a journey are performed under very different regulations. It should be added that the use of wireless in our marshalling yards will become more particularly necessary when they have been re-arranged along new lines in such a way as to enable the maximum efficiency of working to be obtained. It is for this reason that in 1947 several large yards were provided with radio-telephonic communication, at the same time as rail brakes and automatic sorting mechanism.

At the same time we are developing other applications of wireless, rather less urgently needed though of undeniable interest, particularly for communicating with the repair lorries dealing with the overhead contact lines and power lines, as well as long distance communication along the main track routes. It is to be noted that the use of « cables hertziens » is being considered, especially on electrified lines.

III. — Restoring of the Calais Marine and Dieppe Marine Stations.

When the question came up at the beginning of 1946 of recommencing the marine services in the ports of Calais and Dieppe, it became necessary to restore the wireless stations there to deal with the various channels of communication called for. The course for the future was seen to be more and more to set up telephonic channels, with the aid of those already in use by international organisations. However, as stated hereafter existing circumstances had to be taken into account which prevented this idea from being carried into effect at the outset.

The determination of the frequencies to be used for these stations necessitated much exchange of views and correspondence between those concerned, in consequence of the large number of wireless channels already in service. It was only on April 12th, or three days prior to the date fixed for bringing the Calais station into use, that the following telephonic frequencies were settled for the four stations concerned as follows :

— Folkestone : 1 705 Kc./s.;
— Newhaven : 1 715 Kc./s.;
— Calais : 1 695 Kc./s.;
— Dieppe : 2 975 Kc./s.

The very serious difficulties facing the manufacturers in obtaining supplies and constructing the two stations did not allow the French National Railways setting them up immediately in their final form. The Dieppe station was the only one put into service with apparatus made especially for the purpose. At Calais, as a temporary measure, recourse was had to one of the sets of equipment described under (II. — 1) above, which had been used to connect Paris and Caen, and which became free at the time. It was necessary to operate, however, on a special frequency, higher than the normal, the temporary equipment not enabling that decided on to be obtained.

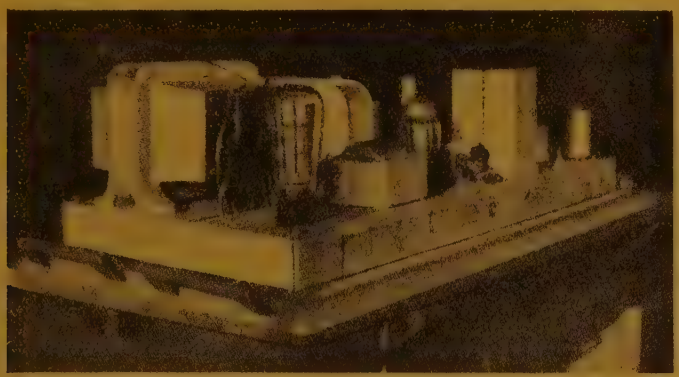


Fig. 6. — Transmitter.

In addition to effecting communication with the mail vessels serving the French and British railway stations, the French National Railways is required, at the request of the Chambers of Commerce, to provide communication between boats belonging to the port and the administrative services in each case. These boats are not as a rule fitted with wireless telephone apparatus and therefore it is necessary to be able to use wireless telegraphy until the use of telephony becomes general. Additional equipment will be installed in the Calais Marine and Dieppe Marine stations, operating in principle on the following frequencies :

1. Simultaneous permanent listening on :

At Dieppe and Calais { 1 650 Kc./s. for wireless telephony; 500 Kc./s. for wireless telegraphy;

2. Transmission :

at Dieppe { 2 975 Kc./s. for both wireless telephony and telegraphy;

at Calais { 428 Kc./s. for wireless telegraphy; 428.5 Kc./s. for wireless telephony.

[625 .242 (.42)]

Large-scale manufacture of wagons, L.M.S.R.

(The Railway Gazette, October 3, 1947.)

In 1923 the unit assembly principle for the production of wagons was introduced at the L.M.S.R. Derby Carriage & Wagon Works, the first wagon to be produced under this scheme being the 12-ton open wagon, with timber underframe and body. Mineral wagons with steel underframes and wood bodies manufactured in the same way were adopted generally in 1935.

plates ¼ in. thick were welded directly to the underframe, and the fixed end, two sides also of ¼ in. thick plate, and end door beam, were assembled to the frame as separate units.

The side, end, and bottom doors were fabricated from plate and rolled sections, but although subsequent tests showed soundness of design and construction, it was decided that by using

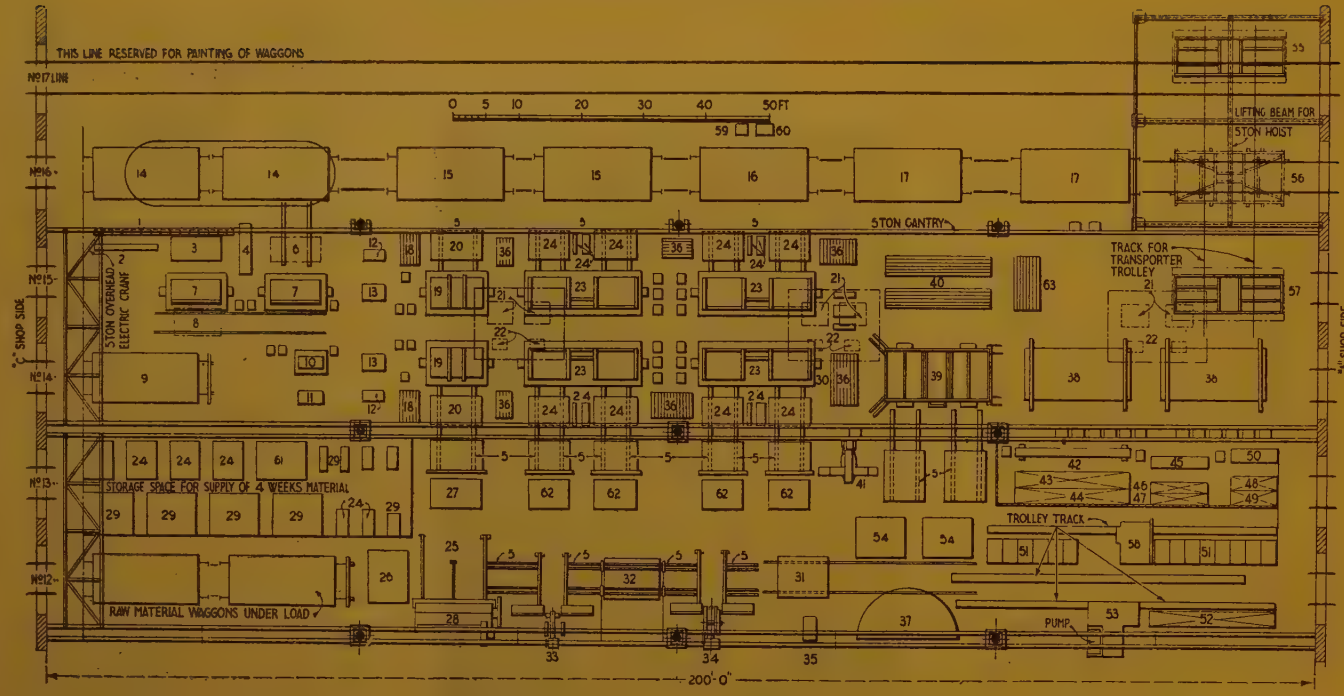
Completed 16-ton all-steel mineral wagon.

To meet the growing demand for wagons of increased capacity, a design was prepared in 1944 for an all-steel mineral wagon which would have a capacity of 16 tons, but retained the existing length and wheelbase. A prototype steel wagon was constructed at Derby Carriage & Wagon Works by early 1945, utilising standard steel underframe components as far as possible, but because of the increase in carrying capacity, larger diameter axlejournals and stronger springing gear were incorporated. Steel floor

steel pressings for the side and end doors, a more easily constructed and neater door could be obtained, and this modification is incorporated in the production vehicles.

During construction of the prototype, a close liaison was maintained between the design office and manufacturing shops, and problems of distortion, inaccessibility of weld, awkward joints, and so on, were overcome. On completion, the vehicle was subjected to shunting and side and end tipping tests,

Large-scale manufacture of wagons, L.M.S.R.



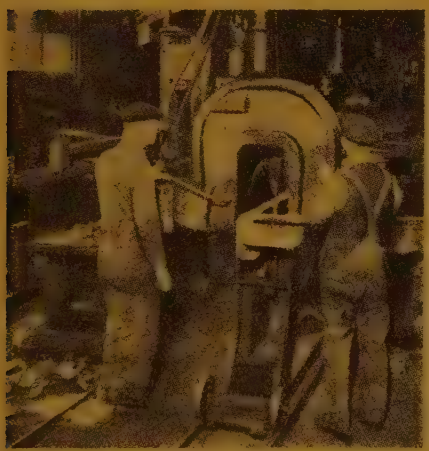
1 Roller conveyor for end door pressings.
2 End door channel jig.
3 End door pressings.
4 End door channels (pressings).
5 Roller trestles.
6 End door complete.
7 End door welding jig.
8 Roller table for feeding end doors to jig.
9 Wagon under load containing side and end door pressings.
10 Side door jig.
11 Side door plates.
12 Bottom door plates.
13 Bottom door jig.
14 Fitting of side, end, and bottom doors.
15 Pent painting position.
16 Riveting door brackets, etc.
17 Welding shell to underframe.
18 End stanchions.
19 Fixed end jig.
20 Fixed end plate.
21 « T » transformer.
22 « C » condenser.
23 Side jig.
24 Side plates.
25 Roller pedestal.
26 Feeding position of plates for guillotine.
27 Storage for fixed end plates.
28 Guillotine.
29 Floor plates.
30 End units complete.
31 Roller top table.
32 Movable portion of conveyor.
33 Punching and notching machine.
34 Notching machine.
35 Single spindle drill.
36 Side stanchions.
37 Radial drilling machine.
38 Rotary welding machine.
39 Tack welding jig.
40 Side units complete.
41 Milling machine.
42 Side angle jig.
43 Side angles for welding.
44 Welded side angles.
45 End door beam.
46 End door beams for welding.
47 Welded end door beams.
48 Stanchions for welding.
49 Welded stanchions.
50 Side stanchions jig.
51 Rack bench.
52 Stacking of angles for sending.
53 Straightening press.
54 Storage for bottom plates.
55 Wagon body on transporter trolley (lifting position).
56 Wagon underframe in position for receiving body shell.
57 Transporter trolley in position for body shell.
58 Cold saw.
59 Rivet heater.
60 Rivet storage.
61 Fixed end plates.
62 Storage for side plates.
63 Door end beams.

General arrangement of special production layout for building all-steel welded wagon bodies, Derby Carriage & Wagon Works, L.M.S.R.

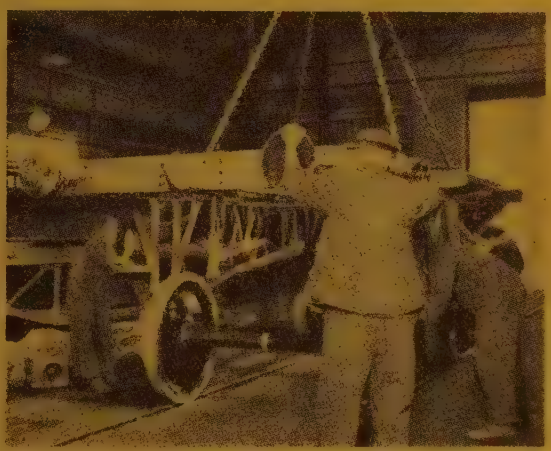
which it passed satisfactorily. From the knowledge gained during the manufacture of this prototype wagon, the present design of all-steel mineral wagon now in production at Derby was evolved.

The existing assembly line in the erection shop is used for the production of the underframe, which is of standard Railway Clearing House riveted design. The main members are cold sawn to length and straightened in mechanical ram type presses. Double-head beam end millers are used for machining the ends of the frame members, and subsequent drilling operations are performed on multi-headed single spindle drilling machines.

Tee and angle sections are welded in required positions on the solebar to provide attachment for the side stanchions and support for the floor plate. These sections, together with the brake-lever guard bracket, side-door check-spring bracket, and doorway angle, are welded in the solebar assembly jig. The solebar channels, which are kept on adjacent racks and brought to this jig down sloping ramps, are accurately positioned end-ways against a dead stop by screw clamps. All details are located and held by swing-over location clamps, which are adjusted easily and swung out of position to allow the complete solebar unit to be slid from the jig down ramps. The jig is pivoted on trunnions which enable down-hand welding to be used in most positions. The base channel of the jig is equipped with an adjustable truss bar, enabling the correct amount of camber to be imparted to the solebar.



Underframe assembly, riveting axleguards to solebar.



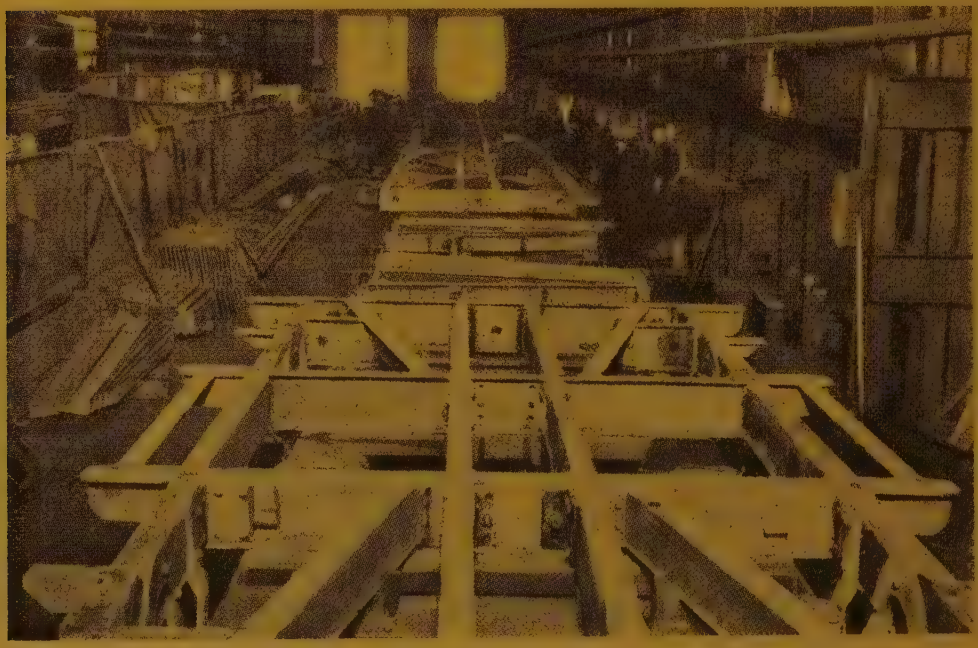
Showing the completed underframe assembly being lowered on to wheels.

The axleguards are hydraulically riveted to the solebar in a wheeled assembly-jig moving on rails positioned to feed the main assembly fixture, as shown in the illustration on the left above. Loading of the other large sub-assemblies into the assembly fixture is assisted by overhead cranes. The frame is bolted sufficiently to secure all members rigidly, and then is lifted from the fixture and lowered on to the wheeled trestles for riveting. The underframe is moved along successive stages where the springs, brakework, buffer and draw-

gear are erected. At the end of the assembly line, the frame is lifted off the trestles and lowered on to the wheels (see page 111); brakework is adjusted, and the frame passed forward for painting and delivery to the body-building shop.

sequence, finished-component loading ramps, and machine section.

The floor plate sequence commences with the plates being crane-loaded on to a ball-bearing topped table, whence the plates are rolled to the guillotine, where they are sheared for fitting up to the



Underframe assembly, main assembly fixture.

Special production layout.

The body is made complete, ready for dropping on to the underframe. A special production layout was installed in three bays in the shop, two of which are equipped with a five-ton overhead crane, and the other bay with a five-ton and ½-ton hoist. To utilise all existing floor space, the welding transformers are supported on platforms slung in the apex of the roof. One bay is limited to component production and comprises a raw-material unloading stage, floor plate adjacent floor plates, and then passed along on roller conveyors to the punching machine. Here the drain holes are punched and then rolled along to the notching machine, where the plates are notched to clear the side stanchions. After this stage, the plates are given one coat of oxide primer paint on the underside, before being transferred to the fixed main assembly tack-welding jig-loading stage. The machine section is equipped with a cold saw horizontal milling machine, radial drilling machine, and a straightening press. All these

machines have some operation to perform in the preparation of the various body framing members before they are passed forward to the assembly bays.

The next bay is laid out for sub and main assemblies; here the body components are jigged and welded together. A complete time-cycle of the assemblies in each jig or jigs was calculated to ensure a uniform flow of assembled parts through the sequence. Revolving jigs, shown in the illustrations, are used, and are evenly balanced when loaded; they rotate through 360 deg. so that only down-hand welding is necessary. On the rotating jigs, contact brushes are fitted to the trunnions to obviate any arcing which would take place between the trunnion and bearing during welding, because of inefficient earthing.

Rotating side-unit jig to complete welds on other side of unit.

Detail welding jigs.

The detail welding jigs have been designed to reduce hand fitting to a minimum and to ensure inter-changeability in subsequent sub-assembly and assembly fixtures. Rotary welding jigs are provided for welding the stiffener web plates in the side angles, gussets in side stanchions, and end-door pins to end stanchions, also for the end-door reinforcing channel for positioning and welding the stiffening web. Fixed jigs are used for the bottom doors and for side doors.

Two jigs are needed for the end doors; the first is designed to fix all items on the end door pressing. The end door head channel pressing is dropped in locating blocks, and the main pressing is dropped on the jig and clamped by swing-over stops and two-way clamps; the stops are set to maintain an accurate dimension from the centre of the hinge line to the tops and sides of the doors, thus ensuring the required bottom clearance on the wagon floor.

The commode handles are located by adjustable clamping-bars swung on the main jig. This jig is used primarily for tack-welding the components into position, and final-welding the hinges and commode handles. The door then is transferred to the rotary manipulator, primarily consisting of two pivoted arms, on which the part-welded door assembly is dropped for final welding.

The fixed end is welded in a rotary jig giving down-hand welding access.

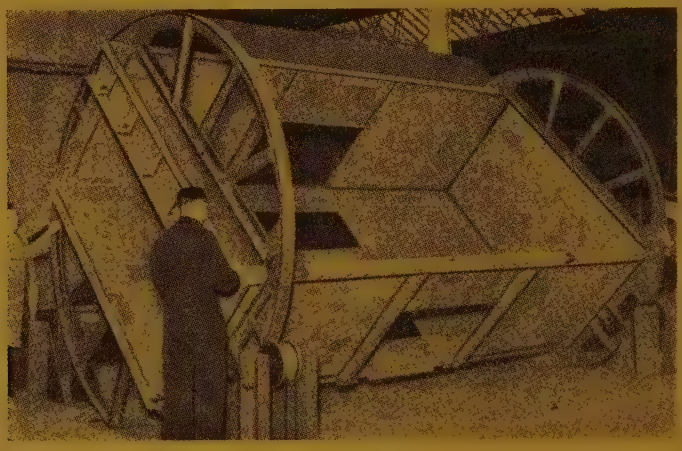
The top angle is dropped into a position on the jig and located endwise by fixed stops. The two end-stanchions are loaded into the jig and located by clamps. Screw-elevated rollers enable the plates to be rolled from the adjacent stack into position, and lowering the rollers automatically drops the plate into approximate position. Clamping is performed by two-way, quick-acting clamps, designed to give pressure in two directions, the pressure downwards is approximately twice the pressure across. The method of location ensures that the overall height of the ends is maintained and that the abutment for welding is accurate.

The side units are welded in a jig very similar in its essentials to the fixed end jig. In this case, fixed-distance quick-acting clamps are provided to maintain correct overall length of the side. The side-door fastener brackets are positioned by taper locating pins, and the plates firmly held in position by swing-over clamps.

Welding the bodyshell.

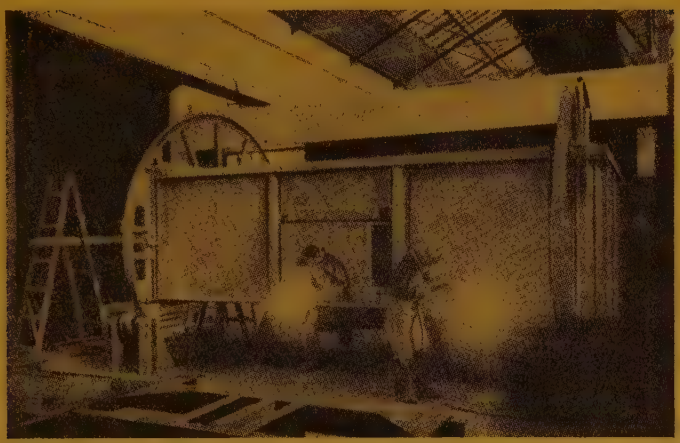
The bodyshell tack-welding jig positions the various sub-assemblies previously dealt with, to form a complete sheel, and quick-acting devices again are used for clamping.

The large floor plates are fed from the adjacent stack through rollers which are elevated and retracted by toggle operated levers. They are tightened by quick-acting side-clamps, and stops ensure the accurate opening for the bottom door. Side and centre plates then are dropped into position against stops to control the door opening. The side- and end-units are dropped into position and secured by the swing-over arms. The bottoms of the side units are forced outwards against stanchion stops by means of a screw-jack; only sufficient tack welding to ensure a rigid shell is undertaken in this jig.



Main assembly jig; rotating the jig to carry out horizontal welds.

The final welding of the shell is undertaken in two manipulators, which consist mainly of two rings; the wagon body is mounted and secured in the approximate centre of the rings. The dimension of the rings is calculated to locate the body about the combined centre of gravity of the body and jig, and the whole is sufficiently well balanced to enable the complete assembly to be rotated easily by two men. The rings



Main assembly jig; wagon body being welded together.

are supported each on two special type rollers mounted in a firm frame forming the foundation of the jig.

The body is loaded into the jigs by breaking the rings at two joints per ring, and swing-over clamps facilitate fastening and unfastening. Clamping screws embodied in the rolling rings grip the body and prevent movement in the jig; locking bars are used to locate the jig in any one of the eight positions for welding (see illustrations). Before leaving this jig, the undersides of the floor plates are given a coat of black bituminous paint.

On removal from the jig, the body is moved through to the third bay on a rail trolley, then, as shown in the illustration, lifted off and positioned on the underframe, using the five-ton hoist for

Completed wagon body being lifted from transporter trolley to underframe.

this operation. It then is secured to the underframe by intermittent welds between the underside of the floor plates and the various framing members, and with a continuous fillet-weld between the floor plate and headstock, at the non-door end of the wagon.

Final processes.

As the vehicle moves along the line, bottom-doors and release-gear are fitted. On arrival at the end of the line, end- and side-doors are hung; they are lifted into position with the aid of the ½-ton hoist. The exterior of the body is cleaned and painted, followed by stencilling and lettering, and the final inspection.

Spot inspection on detail and sub-assembly work is made, and to ensure that a high standard of welding is maintained, periodic efficiency tests are given to the welding operators. No. 6 S.W.G. electrodes are used throughout the construction of the body, which involves some 470 ft. of welding, A.C. welding is used throughout. The weights of body units and amount of weld for each unit are as follows :

Unit.	*No. per vehicle.*	*Weight (lb.)*	*Length of weld (ft.)*
Body die (r. and l.h.)	2	1 024 (each)	70 (each)
Fixed end	1	545	33
End-channel	1	248	22
End-door	1	607	38
Side-door	2	202 (each)	5 (each)
Bottom-door	2	119 (each)	20 (each)
Complete body	1	5 400	470

[624 .63 (.42)]

Prestressed concrete bridge beams being tested in England,

by R. L. M'ILMOYLE,

Assistant Engineer of Structures, London, Midland & Scottish, London, England.

(*Railway Age, September 20, 1947.*)

On the London, Midland & Scottish it is recognized that precast, prestressed reinforced concrete beams have a number of theoretical advantages when used in bridge construction under certain conditions. To determine whether these advantages are borne out in actual practice beams of this design have been in-

Construction view of Adam viaduct, showing transverse tie rods being inserted through the newly-installed prestressed, precast concrete beams.

corporated in a bridge that was recently reconstructed and which is now under observation. Before describing the design and method of construction it may be well to relate in some detail the considerations leading to the decision to conduct the experiment.

When the first British railways were built there was already a well-developed system of main and secondary highways. The acts of Parliament that authorized construction of the various lines required that public roads should be carried under or over the rails, and grade crossings avoided wherever possible. As a result, while there are relatively few large bridges on the British railways, the average number of bridges per mile of track is much greater than on American railroads. Thus the London, Midland & Scottish, with 6 800 route miles (19 200 track miles) has just over 27 000 bridges, or an average of 4 per mile. On the other hand there are only slightly more than 1 100 grade crossings, or an average of one every six miles.

Because the density of traffic is high it is generally only possible for maintenance and construction forces to get possession of the tracks for short periods, usually at week-ends. As a result, the upkeep and renewal of these bridges present a considerable problem. Further, it is seldom possible to alter the alinement and construct a new bridge on a site alongside the existing one, although in some cases the new superstructure is constructed on temporary work alongside the existing bridge and rolled into position in one short possession.

In the case of underbridges (*) the problem of renewal is further complicated by the fact that clearances are fixed by statute and the available constructional depth often imposes severe limitations on the design. Occasionally this can be increased by lifting the track but frequently such a lift is restricted by the existence of overbridges (**) in close proximity to the underbridge.

For over a decade the L.M.S. has, wherever possible, carried out bridge reconstructions in precast reinforced concrete. This practice was adopted following more than a quarter of a century of satisfactory experience with this type of construction on the Northern Counties Committee, a subsidiary of the L.M.S., in Northern Ireland. Its advantages can be summarized as follows :

Reduced maintenance. — The climate of Great Britain is severe on steel; painting generally must be carried out at least every six years and in some cases every two years. In spite of this, corrosion is often heavy and repairs are frequent. Reinforced concrete, properly made, has been found to require little or no attention.

Ease of manufacture and erection. — The units are manufactured in the company's own depot under shop conditions, and production can be carried on throughout the year. The units can be easily placed with minimum delays to traffic, as little or no speed restriction is necessary after erection.

Continuous roadbed. — A ballasted deck, with the advantages afforded by continuity of the standard track construction, is easily provided. Ballasted timber decks have a short life in Great Britain and are now inadmissible on the L.M.S. The greater mass of the concrete units gives a smaller period of vibration and, consequently, a less lively track over the bridge.

Reduced cost. — In most cases the precast concrete bridge is cheaper in first

(*) In Great Britain bridges carrying the tracks over public roads, rights of way, rivers, other railways, etc., are classified as underbridges.

(**) Bridges carrying public roads, rights of way, other railways, etc., over a railway are classified as overbridges.

cost than the steel bridge and is decidedly cheaper in annual cost.

The only serious disadvantage of precast concrete units is that they generally require a greater constructional depth than steel.

When first introduced the precast units were designed as slabs — generally one or two per track. These were used for relatively short spans, as the crane power available was not able to handle loads of more than 10 tons.

About 1924 the T-beam type, in which the deck consists of four or five independent T-beams placed side by side, was introduced, and when cranes of greater capacity became available about 1934 it was possible to renew spans up to 40 ft. in length with such units. A typical cross section of one of these spans is shown in Fig. 1. While this design was economical and very successful the constructional depth required was considerable, with the result that, because sufficient space was not available, the beams could not be used in many cases.

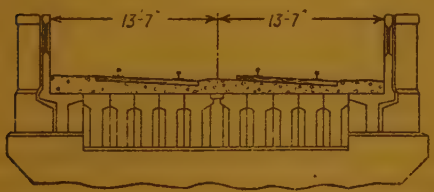


Fig. 1. — Cross section of bridge deck, showing typical construction with precast unit of the T-beam type.

Prestressing investigated.

The use of prestressed, precast concrete had been investigated before the outbreak of war but was not pursued. Some prestressed, precast beams were manufactured early in the war for emergency use in road bridges by the Ministry of War Transport, and the experience gained suggested a further study of the use of this method for underbridges. A comparative design for a particular bridge was made and showed that, while the T-beam design required a depth of 51 in., the prestressed beam would be 10 in. shallower, i.e., 41 in. deep. The weights of the beams for each 2 ft. of width were 18 tons (long) and 14 tons, respectively. The area of reinforcement required for the T-beam was 15.9 sq. in. for the 2-ft. width, compared with only 4 sq. in. (high tensile) for an equivalent width of prestressed beam. It was decided to construct an underbridge with precast, prestressed beams to determine if these theoretical advantages would be obtained in practice. For various reasons it was not possible to carry out the work until 1946 when the renewal of a timber bridge, known as Adam viaduct, was undertaken. This bridge carries two Class I tracks on the line between Manchester and Liverpool.

As a structural material concrete suffers from the great disadvantage that, though it is strong in compression, it can carry little tension. In normal reinforced concrete the tension stresses are carried entirely by the steel, no allowance being made for the tensile strength of the concrete, which is assumed to have cracked to the neutral axis. Thus, the concrete below the neutral axis makes no contribution to the strength of the beam in bending. This disadvantage can be overcome by inducing a compressive stress in the concrete sufficiently great to ensure that under full load the maximum value of the tensile stress does not exceed the allowable tension in the concrete. There are two principal ways of inducing the prestress : (1) Applying a prestressing force to the cured concrete (sometimes called poststressing); and (2) casting the concrete around steel already prestressed. The latter method was adopted. If the prestressed steel is efficiently anchored,

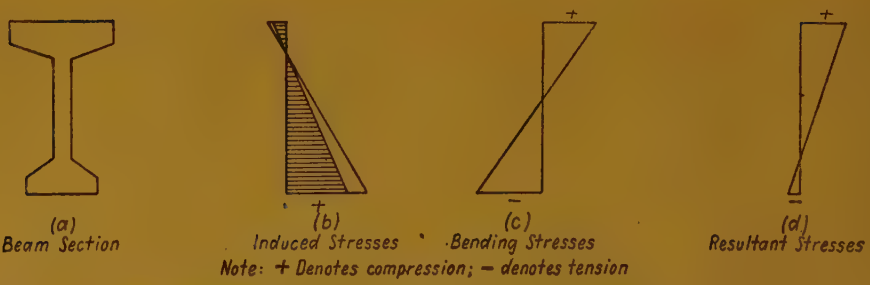


Fig. 2. — These sketches illustrate the principle involved when the reinforcing in a concrete beam is prestressed.

the tendency of the steel to return to its original length will cause compression in the concrete.

In simple beams of the prestressed type the prestressing reinforcement is placed in the bottom flange; the eccentricity gives a maximum compressive stress in the bottom flange and generally induces a tension stress in the top flange. The whole of the induced prestress is not available for resisting the bending stress as a portion of it is released by elastic shortening of the beam, plastic yield, and shrinkage of the concrete.

Rebuilding Adam viaduct.

The stress distribution after prestressing is shown in Fig. 2(b). The net amount available after making allowance for the three factors referred to above is indicated by the cross-hatching on this figure. The stress caused by the dead and live loads is shown by Fig. 2(c) and the final stress condition is shown by Fig. 2(d). The small tension stress in the top flange has been converted into compression and the large compression stress in the bottom flange has become a small tension stress. The compressive stress induced by the prestressing also reduces the diagonal tension stress, so that in most cases shear reinforcement is unnecessary.

Details of Adam viaduct are shown in Fig. 3. This structure, carrying two tracks has four openings each 30 ft. long. In the original structure the abutments were masonry and the intermediate supports were timber bents supported on masonry foundations. The superstructure consisted of timber beams (braced

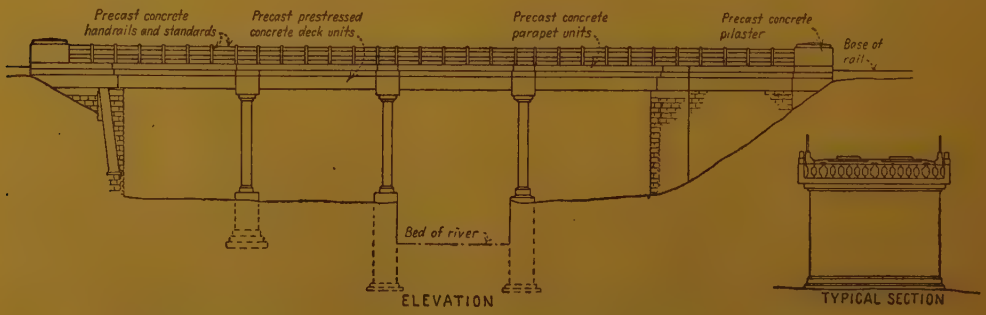


Fig. 3. — Details of Adam viaduct as reconstructed using a design incorporating prestressed. precast concrete beams.

from the bents and abutments) carrying a timber deck. In the reconstruction work the timber bents were replaced by concrete piers constructed on the old fundations, and the deck was formed of precast, prestressed I-section beams. The beams are 32 in. deep, the top flanges have a maximum width of 20½ in. and the bottom flanges are 16 in. wide. At the center of each beam the web is 4 in. thick, gradually increasing in thickness towards the ends from about the third points.

The small spaces between the top flanges of adjacent I-beams under each track are grouted, and three 1¼-in. high-tensile rods, placed transversely and stressed by means of nuts at each end, fix these members together so that they act as a single unit under live load. Two beams on each side of the deck support the parapet units. All beams were placed individually and the grouting and transverse stressing were carried out after erection.

Each beam is designed to carry 20 per cent of the total live load per track, which is taken as 20 units of the British Standard Loading for Railway Bridges (approximately E45) with an allowance for impact of 59 per cent, which was based on a report of the Bridge Stress Committee made in 1928. The prestressing reinforcement in each beam consists of 42 high-tensile wires, each ⅕ in. in diameter, placed in the bottom flange. This reinforcement is prestressed to 70 tons per sq. in. and 20 tons of this initial tension are considered as being absorbed by elastic shortening, plastic yields, etc., leaving 50 tons effective for carrying the load. This gives an effective prestress under no load of 1 350 lb. per sq. in. compression in the bottom flange and 290 lb. per sq. in. tension in the top flange. The application of the live and dead load gives a resultant bending stress of 190 lb. per sq. in. tension in the bottom flange and of 1 100 lb. per sq. in. compression in the top flange. The shear stress at the support is 260 lb. per sq. in. at the neutral axis, the compression component is 350 lb. per sq. in. and the tension component is 139 lb. per sq. in.

Methods of manufacture.

The units were manufactured in the company's precast concrete depot at Manchester where a prestressed concrete casting bed had been laid down. This bed consists of two massive concrete abutments, approximately 900 ft. apart, with a concrete paved area between, on which the bottom forms for the units were leveled. The abutments were sufficiently wide to enable three rows of beams to be cast at one time.

The high-tensile wire was supplied in coils, each containing a length of wire slightly longer than the distance between the abutments. The wire was straightened, cleaned and stretched between the abutments, passing through spacing plates and an anchor plate at each abutment consisting of a heavy steel slab in which holes were drilled. Two wires were passed through each hole and then anchored in place by a tapered plug acting as a wedge. Care was taken to ensure that all wires would have the same initial tension. When these had been fixed and secured the anchor plates where jacked against the abutments until the total prestressing force had been induced in the steel. The prestressing force was measured by a calibrated gage on the jack and checked by the amount of travel of the anchor plates.

The anchor plates were then firmly fixed in position by wedging from the abutments. The stirrups or binders were placed round the stretched wires, and the side and end forms placed in position, with small gaps between the beams. The concrete was then placed and when this had reached the desired strength (6 000 lb. per sq. in. at 28 days) the prestress was induced by gradually releasing the anchor plates. The short-

ening of the wires that then took place was sufficiently powerful to move the completed units on their base. The short lengths of wires between the units were then cut with an oxy-acetylene torch and the units lifted to storage. The process was then repeated until the desired number of beams had been manufactured.

Fig. 4 is a view looking along the casting bed from one of the anchorages. Only the last few beams in this set-up remain to be completed. The forms have been fixed in place and are being lined preparatory to concreting. The projecting steel sections in the foreground take the jack reaction during the prestressing and the anchor plate, with projecting lengths of wire, is clearly seen.

Fig. 5, showing a length of the casting bed on which the beams have been completed, was taken before the prestress had been released. The method of casting the beams in a continuous length is clearly shown, and a number of beams which have already been precast are seen stacked in the background.

Fig. 4. — Casting bed for the prestressed beams used in Adam viaduct, showing completed beams in background, forms being assembled in middle area, and anchorages for wires in the foreground.

The high-tensile wire used is hard-drawn, 0.2 in. in diameter, made of a specially-improved patent steel with a guaranteed breaking strength of 100 tons per sq. in. (224 000 lb. per sq. in.). Although the wire was specified to be

degreased and free from soap or water, it was carefully cleaned by a wire brush during straightening to insure that there would be no difficulty in obtaining adequate bond.

Secondary reinforcement and stirrups were of ordinary mild steel. The concrete mix was designed to have a minimum crushing strength on 6-in. cubes of 6 000 lb. per sq. in. at 28 days or 4 000 lb. per sq. in. in 7 days using a high-early-strength cement. There was no difficulty in obtaining this strength.

The mix used was approximately 1:3½ (30 per cent sand), and the water-cement ratio was about 0.45. The concrete was vibrated into position with external vibrators, as internal-type vibrators were not available at the time of manufacture. The tension wires were released after the last unit cast had attained the specified strength.

Loading tests were carried out on two of the beams by supporting them at the ends and applying a point load at the center by means of a jack reacting against a temporary load. This test load was equivalent to the designed load plus 50 per cent, which required the application of a point load of 26¼ tons (long). The maximum deflection recorded in the case of one beam was ½ in. and in the other, $^{9}/_{16}$ in. In both cases there was no permanent deflection and the beams returned to their original « hogged » condition after removal of the test load. There was no sign of cracking during the test. The beams were stored at the depot and dispatched to the site as required by the erection operations.

Fig. 5. — This view, which shows a length of the casting bed on which the beams have been completed, was taken before the prestress had been released. Note stored beams in the background.

Placing the beams.

The operating department was unable to agree to any track possessions other than at week-ends, and it was ultimately decided that the erection of the bridge should be carried out by removing the

existing structure and replacing the piers with military-type steel bents and the deck with temporary steel girders carried by these bents. By this method it was possible to construct the new piers during the week without interfering with traffic over the bridge. When the piers had been completed a portion of the temporary deck was removed and replaced with the new beams during week-end possessions.

placing it in position was about ten minutes, but with a fast-acting crane this time could be substantially reduced.

When the beams under a track in any particular span had been put in place the transverse tie rods were inserted in the holes provided in the top flanges and, after the grout had been placed between the units, the rods were stressed by operation of the nuts, using a calibrated tension spanner. The ballast

Fig. 6. — Underside of Adam viaduct following its reconstruction with prestressed, precast concrete beams.

The original schedule provided for the placing of the new deck in four separate operations, the units in two spans on one track to be dealt with in each operation. The first two operations were carried out as scheduled but the experience gained indicated that it would be possible to carry out the remaining two operations in one occupation. This was arranged and was easily carried out in the allowed time. Since the only cranes available were very slow in operation, the average time for lifting a beam and

was then placed and the new track laid.

While the units were manufactured in the company's depot the actual erection work was carried out under contract, the temporary trestles and deck being provided by the company and installed by the contractor.

As mentioned, earlier, Adam viaduct was reconstructed in this way as an experiment to determine whether the use of prestressed concrete offered any advantage for the reconstruction of underbridges. It should be pointed out, how-

ever, that an essential aspect of the prestressing is the use of a high-strength concrete (6 000 lb. per sq. in.), whereas the concrete used for the normal type of precast underbridge has a compressive strength of only 3 000 lb. per sq. in. If the higher quality concrete were used for ordinary precast work the depth required for the T-beams in the comparative case referred to earlier could be reduced from 51 in. to 46 in. and, if a small quantity of compression steel were added, the depth could be reduced to that of the prestressed beam, i. e., 41 in.

A careful analysis is now being made of the costs of both methods to determine whether or not it is economical to employ prestressed concrete as against the normal type of reinforced concrete using higher grade concrete with suitable increase in the working stress. Pending the results of this investigation, it is felt, however, that there is a considerable field for the use of prestressed concrete for work of this type. Investigations are now proceeding on the possibility of utilizing it for production of slabs required for smaller bridges of which there are a considerable number with small available constructional depth.

The last units were placed in Adam viaduct at the end of May, 1946, and so far there has been no sign of distress or defects in the structure, although the elapsed time has been too short to permit any conclusions to be drawn regarding their behaviour under traffic.

[621 .135 .4 (.494) & 625 .215 (.494)]

Tests of bogie-control device.

(*Engineering, September 12, 1947.*)

In Switzerland, where not only carriages and wagons, but also electric and Diesel-electric locomotives are commonly constructed with a pair of bogies, and where curves in the track are numerous, the control of bogies to promote smooth running and reduce flange wear is of particular importance; and the Swiss Locomotive and Machine Works, Winterthur, have devised a simple coupling to effect this, as well as apparatus for demonstrating the principles involved. A pair of four-wheeled, or six-wheeled, bogies are joined by a spring coupling at the ends of two yokes on the bogies, as illustrated in Fig. 1; a diagrammatic section through the spring coupling is shown in Fig. 4. A general view of the experimental apparatus is given in Fig. 2, and a closer view of the model bogies and associated apparatus in Fig. 3.

As shown in Fig. 2, the apparatus consists of a horizontal wheel, which may be rotated by hand or by means of an electric motor, and the upper edge of the wheel represents the track. It is, therefore, the circular track which moves, the bogie being held stationary by a cord connecting the front of the leading bogie with any convenient fixture. The « track » consists of two parallel flat paths, with a wide shallow groove between them. There is no superelevation, as the stationary bogies are not affected by centrifugal force, unless this is artificially simulated by a pull on a cord attached to the side of the bogie, as shown in Fig. 3. Each bogie consists of a rectangular steel block with

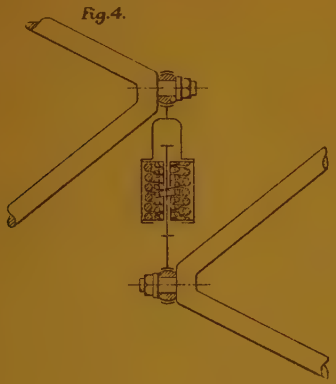
Fig. 1. — Coupling applied to two bogies.

Fig. 3. — Model bogie arranged for test.

Fig. 2. — Model-bogie testing apparatus.

four wheels or rollers without flanges, and the bogie is constrained to remain on the track by two guiding wheels, one at each end, on the underside of the block with their axes vertical. These guiding wheels run in the shallow

Fig.4.



groove of the track, and are smaller in diameter than the width of the groove, to allow some lateral movement of the bogies. They thus resist the lateral forces which are normally absorbed by the wheel flanges, and such forces are readily measured by means of four Huggenberger tensometers, which are fitted one at each end of each bogie, as shown in Fig. 3. The bogie pivots are connected by a light frame which represents the underframe of the vehicle; and the coupling to control the motion of the bogies is, in this case, a simple arrangement of links without any springs. The behaviour of a bogie, and a pair of bogies, on a curved track may now be described, by referring to the experimental apparatus, which adequately demonstrates the phenomena.

Considering a single independent bogie : as soon as it is propelled on a curved track (or, as in the apparatus, the track is propelled in relation to it), it assumes a position in which the rear axle tends to be radial to the curve, and the front outside and rear inside wheel flanges exert forces on the outside and inside rails, respectively. In the model, these forces are resisted by the guiding wheels and measured by the tensometers; and, as the model shows, the forces will act without any centrifugal force. It may be shown that the forces increase with the load on the axles, but the speed has no appreciable effect. If, now, an increasing lateral force — a centrifugal force, for example — acts at the centre of the bogie radially outwards, the rear axle will gradually shift over towards the outside rail, and eventually, when the lateral force has reached a certain value, it will cause a flange force to be imparted to the outside rail by the rear outside wheel (or by the guiding wheel, in the case of the model). The value of the lateral force, which is required to cause the rear outside wheel flange to make contact with the rail, may be calculated, and depends on certain characteristics of the bogie and track. Simultaneously, the increasing lateral force adds to the flange force of the front outside wheel, but not to the extent that would be expected by considering the moment of the lateral force on each axle; and the movement of the rear axle to the outside reduces the angle of incidence or « attack » of the front outside wheel flange on the curved rail. The rate of wear of the flange is a function of the angle of incidence and the flange force. The rate of wear of the front outside wheel flange, therefore, will tend to increase with the increase in the lateral force which is applied to the bogie, due to the increasing flange force; but in certain cases the rate of wear of the front outside wheel flanges may decrease due to the effect of the smaller angle of incidence. This behaviour of a bogie subjected to a lateral force while travelling on a curved track, shows that centrifugal force has not as much influence as is generally believed on flange forces and rate of wear.

Consider, again, the motion of a single

bogie on a curved track. If a lateral force acting towards the outside of the curve is applied to the bogie (or a rear extension of the bogie) on its longitudinal centre line at a point to the rear of the rear axle, the flange force of the outside front wheel is reduced. As the lateral force is increased the rear wheels tend to move away from the inside rail towards the outside rail, and, when a certain value of the lateral force is reached, the flange of the rear outside wheel rides on the outside rail, similarly to that of the front outside wheel. A further increase of the lateral force reduces the flange force of the front outside wheel to zero, and the front axle is then in a state of unstable equilibrium. This is undesirable, because the front axle and wheels may oscillate laterally very violently between the rails.

Another experiment with a single bogie shows that the natural tendency of a bogie on a curved track to assume the out-of-line position which has been described already, may be corrected, and the bogie guided entirely, by a lateral force directed towards the inside of the curve and applied forward of the front axle on the longitudinal centre line of the bogie. These two methods of guiding a bogie on a curved track, namely, a lateral outwards force at the rear of the bogie, and a lateral inward force at the front of the bogie, are applied to the front and rear bogies, respectively, of a vehicle, by coupling them together as shown in Figs. 1 and 4, so that they mutually correct the tendency of each to assume the out-of-line position. The bogies are coupled by two triangular yokes, one on each bogie, connected together by a spring coupling (Fig. 4). The spring coupling allows an initial side-play, which may be adjusted to any value between 20 and 50 mm. ($^{25}/_{32}$" and $1^{21}/_{32}$"); and further relative movement is controlled by two helical springs, which may be adjusted to allow a maximum movement of 24 mm. ($^{15}/_{16}$"). As Fig. 4 shows, relative movement of the yokes may be towards or away from each other, and such a provision is clearly desirable for the occasions when the vehicle is traversing a section of track in which the radius of curvature varies between the bogies. Relative angularity of the two bogies is allowed by the ball joints between the ends of the spring coupling and the two yokes.

At its best, this connecting device will ensure that the two bogies are guided almost wholly by the front pair of wheels of the leading bogie, and, in any case, it reduces the angles of incidence of the wheel flanges on the rail, reduces the flange forces, and consequently the wear of flanges and rails. In certain cases, however, it is possible for the bogies connected by this device to be unstable on a curved track; but this can be checked when designing the vehicle, and avoided by careful design and suitable adjustment of the spring coupling.

NEW BOOKS AND PUBLICATIONS.

[385 .02]

The Universal Directory of Railway Officials and Railway Year Book, 1947-1948. — London: The Directory Publishing Company Limited, 33, Tothill Street, Westminster, S.W.1. — 604 pages (8½ in. × 5½ in.) (Price: 20 s. net.)

The Universal Directory of Railway Officials and Railway Year Book 1947-1948 reaches with the present volume its 53rd year of publication.

The first edition was compiled from official sources and issued in 1895, and at that time some 270 pages sufficed to cover the text including an index to countries, an index to names of railways and the comprehensive personal index of railway officials which is still a noteworthy feature of the volume.

The present edition should prove at least as valuable as its predecessors in containing within the scope of little more than 600 carefully-condensed pages more comprehensive lists of officers and particulars of railways throughout the world than can be obtained from any other publication in any language.

The information contained in this volume enables railway officers and others to keep in touch with the personnel on railways throughout the world for the exchange of information concerning research and developments in all phases of railway operation and maintenance. The order in which entries appear has been selected so as to group all the railways in the United Kingdom, the British Colonial Empire, and the Dominions in sequence, followed by the railways of foreign countries.

For ready reference purposes at the end of the volume will be found three indexes:

1) an index to countries;

2) a general index including all references to railways and statistical and other information;

3) a personal index of railway officials.

[656 .235]

PAILLARD (A.). — Commercial Superintendent attached to the General Management of the Swiss Federal Railways. — **Les Tarifs de Chemins de fer en matière de marchandises** *(Railway goods rates)*. — One volume (6¼″ × 9½″) of 302 pages with figures and graphs. — 1945, Lausanne, Librairie de Droit R. Roth & Cie.

The question of railway rates is of particular importance in Switzerland. Various circumstances native to that country contribute towards increasing the effect of the current rates on the economic life and prosperity of the railways, for example the great number of lines operated by different companies, the special conditions under which concessions were granted, the competition of road and other methods of transport, the geographical position of the country which gives rise to complicated transit traffic, and the mountainous nature of the country which causes difficulties in making and operating lines.

A study of the evolution of the rates in Switzerland was therefore a very tempting field for an economist. It would be a very lengthy task in view of the diversity and great number of interests concerned and the profound

changes made in the administration of the railway. The work of Mr. PAILLARD has pratically exhausted the subject. No point in this vast field has escaped his attention. In writing the history of the rates, he has at the same time evoked the history of the railway itself under one of its most interesting aspects.

Mr. PAILLARD has based his work on a firm foundation by beginning with a description of the general principles on which the goods rates have been based. The way he has done this gives the reader a thorough knowledge of the subject so that now he only has to extend his knowledge by consulting the many sources indicated in the bibliography. In the chapter dealing with the classification of the rates, he pays special attention to competitive rates. He returns to this question of competition later on in his book. The description he gives of the efforts made to achieve co-ordination of transport, the discussion to which they gave rise, and their consequences, is extremely instructive. It should be read very carefully by all those who wish to solve this difficult problem.

The second part, one passionate chapter of which we have already mentioned, gives a detailed description of the evolution of rates in Switzerland since before 1882. The granting of concessions by the Cantons led to a chaotic state of affairs. Many years passed before uniform rates were agreed. They were only obtained after the buying up of the different lines afterwards operated as the Swiss Federal Railways. Reform of the rates was a very lengthy and roundabout affair. The author divides his report into several different periods: from the buying up of the railways to 1914, the time of the first world war and post-war years, the 1929 rates, the second world war, and the rating position at the end of 1945.

Mr. PAILLARD has written a book of great theoretical and positive value. The numerous figures, graphs and numerical tables which illustrate the work will satisfy the requirements of the most critical.

In the final chapter, he gives an authoritative definition of the role and position of the railway in the face of modern technical progress, and he gives us a striking picture of the possibilities opened up by the long distance transport of fluids of the most diverse kinds.

E. M.

[621 .133 .7]

FOX (B. D.), member of the Institution of Locomotive Engineers. — **Soft water for loco boiler feed.** — One volume ($5\frac{1}{2}'' \times 8\frac{3}{4}''$) of 116 pages and plates. — London, The Locomotive Publishing Co. Ltd., 88, Horseferry Road, Westminster, S. W. 1.

The purifying of water for locomotive boilers must be approached with a certain caution. Though it is desirable to reduce as much as possible the deposit of scale on the plate and tubes, precautions must also be taken against the dangers of corrosion in the case of water treated by certain methods. Moreover the phenomena of priming which is so bad for the cylinders is due to a concentration depending largely upon the behaviour of the precipitable salts.

The value of water softening is so great that many Administrations have voted large sums for installations of this kind. However opinions are still divided as to the merits of the different processes. The question in fact is a very complex one and investigations into the reactions occurring during the process of

treatment and subsequently in the boiler are only possible when special information is available.

Mr. B. D. Fox's book will be a great help to those who are not professional chemists. As Sir Montague J. EDDY, C.B.E., says in a short preface, the author has very considerable experience of water purification and sees things from an essentially practical point of view.

In the first part, he reports the essential facts and shows how the object in view, namely the elimination of salts likely to form a deposit, must be pursued whilst avoiding two stumbling blocks, namely corrosion and priming. The latter point is dealt with at length, and is further mentioned when dealing with the economic aspect of the methods used.

In the second part, the author reports the six principal methods known and used for water softening. He classifies them according to the chemical reactions upon which they are based, the kind of water to which they are best suited, the properties of the water after treatment, and the results which can be obtained by their use, as well as the drawbacks to which they may give rise.

The third part is an application of the ideas reported in the two first parts. Under well determined conditions of service and the behaviour of salts as found in current practice, the author determines the reactions and quantitive results obtained by the use of the different processes. In this way he is able to give a reasoned appreciation of the method to be selected, taking into account the original nature of the water and its possible action after treatment on the metals used for boilers and pipes.

E. M.

[385. (09 .2 (.494)]

MATHYS (E.), Librarian of the Swiss Federal Railways, in collaboration with H. MATHYS of Berne. — **Manner der Schiene, 1847-1947** *(Railway Men, 1847-1947)*. — One volume ($5\frac{3}{4}'' \times 8\frac{1}{4}''$) of 280 pages, illustrated. — 1947, Berne, published by the Author. (Price : 6.50 Swiss francs.)

The celebration of the centenary of the first Swiss Railway line seemed to the author to be an opportune time to fill a gap which has often been deplored. Up to the present, there has been no general biography of the railway pioneers. This was the more regrettable as the creation and development of the railway in Switzerland though often coming up against great difficulties, also met with very varying changes of fortune. Technicians, geologists, and economists will all be interested in reading these pages of Swiss railway history, as it is indeed a historical record to describe briefly the life and work of men, who devoted the best part of their lives to the railway.

Owing to its geographical situation, Switzerland and her lines of communication have a great importance from the international point of view. This explains the intervention of adjoining countries in the construction and financing of certain lines through the Alps. There is therefore also a political aspect to the railway question which the author evokes when he describes the actions and influence of those who were most closely concerned with the creation of the railways.

It is a very moving book. The activities of a brilliant group of railway men are unfolded during a recital of the creation, investigations, labours, discussions and patient efforts, which resulted in the present magnificent railway sys-

tem. The reader is led to share the author's admiration for the probity, perseverance, patriotism and enthousiasm of these men.

They number forty-four, and the author explains how difficult he found it to make his choice. We understand his regret in having to limit the scope of his book.

By a happy inspiration, he has been able to head each biography with an engraving of the person concerned, which will be much appreciated by many readers. Though there are not many illustrations, those selected are very appropriate. The most memorable events in the history of the Swiss railways are illustrated by engravings.

The author indicates the sources from which he has collected the facts related in each biography. His list forms a comprehensive bibliography to which who wish to increase their knowledge of the history, technique or general organisation of the railway may well refer.

E. M.

[385. (02]

Les mystères des Chemins de fer *(Mysteries of the Railways).* — Technique-Operation, by a group of engineers, whose essays have been collected and edited by Ernest GUT of Bâle. — One volume ($6\frac{3}{4}'' \times 9\frac{1}{2}''$) of 406 pages, with 213 illustrations, 69 plates of which 5 are colour drawings. — 1946, Lausanne, Publishers F. Rouge & Co. Ltd.

Those concerned with the operation of a railway often have occasion to note how little their clients understand the complexity of the internal organisation of the railway. Most passengers think the railway begins and ends with the equipment and staff they encounter at the stations and on the trains. Many industrial firms, who load several wagons a day, have never given a thought to the problem of allocating empty wagons.

This is why when these authors speak of railway « mysteries » they mean a whole lot of things, which are not hidden from the curious eyes of the public but merely ignored by them. Actually speaking certain things, for example remarkable engineering structures, are there for all to admire, but apart from the specialists and certain well-informed amateurs, the passenger is not interested except when he can see the depth of the valley or the height of the precipice which the railway enables him to cross. Again, how many buildings, appliances and equipment have been designed to improve the working of the railway still further. Although many of them can truly be called marvellous, they are nearly all completely unknown to the public. This is much to be regretted. Both from the point of view of knowledge itself and to be able to appreciate at its true value the considerable work involved in making and running a railway, it is very interesting to see the veil which hides so many mysterious things being lifted by specialists.

The material at the disposal of the authors was very copious. In Switzerland, where electrification is highly developed and civil engineering works abound, they could give the reader much upon which to meditate and be amazed. They have reaped widely and few fields have escaped their investigations.

Whether dealing with the foundations of the permanent way, the equipment of the track, or the rolling stock, they have stressed the essential facts and underlined the most remarkable events. The operating methods and equipment used are perhaps more likely to interest the

public, as they reveal more of the complexity of the internal organisation of a railway. By dealing with the collaboration of firms supplying the railways, the authors have been able to describe many very ingenious appliances and constructions. This may be taken as a proof that the Swiss Federal Railways are making every effort to improve their system unceasingly, both from the point of view of efficiency and of security, and also as a tribute to Swiss industry.

We may end by saying that this beautiful book is copiously illustrated. Many of the drawings are remarkable not only for their variety and their artistic value, but also for the clever way in which they have been selected in order to bring out salient points.

E. M.

[656 (.492)]

VAN MARLE (Th. M. B.), Engineer, General Transport Superintendent, Holland. **Overheidsbemoeienis met het vervoer.** *(Intervention of public authorities in transport).* — A pamphlet (6½" × 9") of 88 pages. 1946. — Published by the « Algemeene Landsdrukkerij » at The Hague. (Price : 1.25 florins.)

The development of transport, both passenger and goods, was a natural corollary of the intensive technical development which occurred during the last century. The application of steam to maritime and inland navigation and for railway transport changed the whole aspect of communications. The subsequent development of the internal combustion engine, especially after the 1914-1918 war, restored to the road the importance it had lost and had profound repercussions on maritime, river and railway transport.

This evolution led the public authorities to intervene more and more frequently by passing legislation affecting transport in order to regulate it as far as possible, prevent unfair competition, safeguard public interests, insist on social measures, and assure safety of operation. Later on such intervention tended to diminish.

Mr. VAN MARLE's book is intended to report the intervention of the public authorities of the country in this field from the special point of view of the Netherlands.

His work is divided into three main parts : he deals first of all with the situation prior to 1914-1918, devotes the second part of his study to the period between the two wars, and finally in the third part describes the facts which characterized the period of occupation during the last war.

There is a highly developed system of waterways in Holland; consequently it is only natural that the first regulations, which were not very extensive, should deal with navigation.

When the railways came into the picture, such intervention necessarily increased owing to the enormous number of different interests involved.

At this point Mr. VAN MARLE gives a history of the development of the railway which ended in the amalgamation of the different companies into a single State operated system under State controlled management.

In the case of the secondary railways the intervention of the State consisted more especially in financial measures when they were built.

The different regulations and interventions were regulated by laws or administrative decrees.

In the second part of the book dealing with the 1920 to 1940 period, the author

brings out the difficult position in which the railways found themselves owing to competition from water and road transport, the serious effects of this state of affairs on the State budget owing to its guarantees, which necessitated the intervention of the public authorities to insure a thorough reorganisation of the operating methods as well as the finances of the railways and stricter limitation of the field of activity of both rail and road.

As a result of the development of motor transport, the State built a vast network of modern highways as well as developping the canal system. The latter in particular was the cause of a profound crisis as far as the railways were concerned, lasting from 1932 to 1939.

As the State had to meet the deficit, it did so by means of a road tax, and set up a central permanent transport commission in order to co-ordinate, simplify and rationalize all traffic.

This is where the extensive reorganisation measures taken by the railways come in : standardisation of the system, suppression of many stations, motorisation and electrification on a large scale on all the main lines.

As far as the secondary railways were concerned, many were suppressed and replaced by omnibus services.

Road transport was first of all brought under control by means of a strict enforcement of a system of concessions.

In the case of water transport, endeavours were made to minimise the serious drawbacks caused by excessive transport being available by regulating the hiring of boats and instituting a method of allocating freights; the question of the system of tolls on the waterways was also examined.

In the third part of the book are to be found details of the steps taken by the Government under threat of war, a brief description of the state of the system as a result of the invasion, the steps taken to restore it, the effect of the restriction of road traffic on the activity of the railways, the requisitioning of railway rolling stock by the Germans, the suppression of rail motor traffic; to put it briefly, the railways had to cope with a relatively greater traffic and, with the consent of the authorities then in power, many steps were taken to simplify the organisation and increase the rates as circumstances dictated.

The public authorities under the influence of the necessities of the moment imposed very severe restrictions on road traffic, justified by the shortage of fuel oils, and these restrictions became more and more extensive. Similar steps were taken in the case of goods transport by road.

Even water transport was brought under a very strict regime, which reached its ultimate limit when the Germans proceeded to requisition boats and barges for military reasons on a large scale.

The railway strike in 1944 and the large scale plundering of road vehicles by the Germans finally completely disorganised transport throughout the country and caused the famine that raged in the western part of the country at the end of the occupation.

Mr. VAN MARLE's book is of great value as a contribution to the history of the economic evolution of the transport system in a densely populated country.

E. V.

[385. (09 (.42)]

« It can now be revealed » — More about the British Railways in Peace and War. — Published by the British Railway Press Office of the G.W., L.M.S., L.N.E.R., S.R. & L.P.T.B. — A pamphlet (7" × 9") of 64 pages, copiously illustrated. — 1945. The British Railways Press Office, 2 Palace Chambers, Bridge Street, Westminster, S.W.1.

The British Railways consider that it is of the utmost importance to keep the public well informed about the problems the railways have to solve and the way in which they solve them. During the war, the publicity to which they were accustomed had to remain silent for security and other reasons. Now that the ban is lifted, it is possible for them to present a picture of their activities during hostilities. This is the primary object of this publication. Its secondary object is to describe the immediate peacetime programme intended to improve still further the services offered to the public.

The railways contributed very largely towards the production of war materials. The most varied equipment came out of their shops. It was above all however in the manufacture of tanks and aerial weapons that their co-operation was of the greatest value. In many cases their research departments drew up the detailed plans and the railways became the control centre for manufactures spread over several firms. A list of the equipment placed at the disposal of the War Office makes impressive reading, and often urgently needed material was made at such short notice as to be a real achievement. The well-equipped railway shops enabled them not only to make the tools they themselves needed but also to supply precision tools to armament firms and so meet a very serious shortage.

Most of the war factories were built alongside the permanent way, and the railways had first of all to transport the necessary materials to build them and afterwards both the raw materials and finished products. Special stations had to be built for workers' trains; omnibus services also were organised.

For though the railways were able to mobilise a large part of their staff and use their own equipment for war materials, they also had to carry out their own job and meet extraordinary demands in this field. The transport of millions of bricks for building aerodromes, thousands of wagon loads of petrol and bombs for bomber raids, and pipes for the pipe-lines, are only a few examples selected from amongst so many which put their remarkable organising capacity to the test.

Most striking of all is the part played by the railways in the invasion preparations. The transport of the landing equipment, military stores of all kinds, and English and American troops, necessitated running thousands of special trains. The three weeks before the 6th June 1944 saw their number increased to 9 679, 3 636 of which were run in a single week. After this, there were still further increases in the amount of traffic carried. In four weeks, 17 500 special troop and provision trains were run.

Whilst this formidable work was being carried out, the railways were also suffering severely from attacks by flying bombs. Vital structures were damaged by these. This was when British railwaymen established new records, traffic often being resumed after a few hours. Only in a few cases was the traffic held up for several days owing to the damage done.

A perusal of this little volume is very affecting. There is one moving episode after another. The efforts required of the railways continually increased. We are filled with astonishment and ad-

miration when we see the task that was accomplished.

Interest is further increased by the many drawings illustrating the text. These give a most eloquent picture of the wartime activities of the railways in the most diverse fields.

One of them, the last, sums up very well the appreciation by qualified authorities of the services rendered. It is most effective in its brevity : it simply says : « Thanks — railways. »

The final chapter sums up the programme which the British Companies hope to carry out as soon as circumstances permit. This covers both improved rolling stock and the renewal of equipment on the most up-to-date lines. The resumption of electrification, held up by the war, is part of the programme. In a vaster field, the British Railways propose to work actively to co-ordinate transport by rail and air, and their views on this subject seem to have been favourably received by the Government.

E. M.

[385. (03 = 439 .81)]

Teknisk Leksikon for Industrie og Haandvaerk. — BIND II : Veje, Jerbaner, Broer, Vandbygning M. V. — (Technical Encyclopedia for Industry and Trade. — Volume II : Roads, Railways, Bridges and Hydraulic Works). — One volume (7 $^{7}/_{8}$" × 10 $^{1}/_{4}$") of 632 pages, copiously illustrated. — 1946, Copenhagen, Selskabet til Udgivelse af Kulturskrifter Kobmagergade, 38.

The publishing firm « Selskabet til Udgivelse af Kulturskrifter » of Copenhagen which has already published a whole series of extensive works and manuals has now greatly enriched Danish technical literature by publishing a series of manuals under the general name of « TEKNISK LEKSIKON ».

The second volume of this encyclopedia, dealing with the technique of roads, railways, bridges and hydraulic works has just been published. It has been edited by a railway engineer, Dr. P. H. BENDTSEN, in collaboration with Professor A. R. CHRISTENSEN and Captain H. A. MATTHIESEN, Engineer.

This is not merely a manual like « Hütte » of great value to specialist, but also deals with a series of technical problems of general interest. With this object in view, many of the specialists of the country were asked to collaborate. For example Professor Anker ENGELUND, Principal of the Danish Higher Technical School, well known for his work in building bridges, has described the great Danish bridges. He has also dealt with well known bridges in other countries, as well as the plan to build a bridge across the Great Belt and the Sund, together with many details concerning the technique of bridge building.

The Chief Engineer of the State Railways, Mr. Sv. THORNING CHRISTENSEN has dealt with questions relative to the construction of railway lines and studies various special questions such as the gauge, laying track on curves, and safety equipment. The chief architect, Mr. K. T. SEEST, has contributed a series of articles about the important station buildings which during recent years have been erected by the Danish Railways under his supervision, such as the Aarhus and Frederica Stations. Other large stations abroad are also described, amongst others the Gare de l'Est in Paris, Cincinnati Station in the U.S.A., Teheran Station, etc...

There are many articles dealing with the railways of nearly all the countries of the world, covering their development, the traffic, organisation, equipment, etc. There is a description of the

underground railways of Paris and Moscow, as well as the « subways » of London, New York and other cities. In particular, there is a description of the Chicago 61 cm. (2′) gauge subway which is intended solely for goods transport, extends to 100 km. (62 miles), and is built 10 m. (32′9¾″) below street level.

Several Danish specialists have studied the question of building roads, and there are interesting articles dealing with motor highways in Denmark and other countries.

The construction of tunnels is a subject about which not much has been written in Denmark to date. As far as this field is concerned, the work in question includes a great number of articles devoted to the technique of building tunnels, descriptions of the great tunnels built to date, as well as the proposed tunnel under the Channel between England and France, the length of which should be 28 miles and which has come up against special difficulties owing to the great depth of the sea (300 m. = 984′).

The Chief Engineer, Mr. Sv. SVENDSEN, General Manager of Hydraulic Works, reports on the construction of harbours and protective works along the coast as well as the question of moving materials. Other subjects dealt with are the construction of canals and hydraulic power installations, amongst others the Boulder Dam in the U.S.A. and the Dnieper Dam in Russia. In this connection, the new science of soil technology receives special mention.

Town planning is dealt with by Mr. O. FORCHAMMER, Engineer, and Professor N. THORKILD-JENSEN. Special articles deal with the construction of silos, reservoirs, stores, blocks of flats, factories, theatres and cinemas, not forgetting the question of acoustics and sound insulation. Various other subjects are dealt with, all with the same precision and clarity, so that the work can be understood even by the reader who knows but little of the subject. In addition the copious and carefully chosen illustrations add to the educational value of this excellent work.

We would like to remind readers that the first volume of the « TEKNISK LEKSIKON », published some time ago, dealt with house building. The third volume, which is in the press, deals with sanitation. Other technical matters will form the subject of succeeding volumes. To sum up, the publishers of this Encyclopedia have undertaken a most praiseworthy task in publishing such an erudite work, which is all the more remarkable in a country as small as Denmark.

[**656** .222 (.42) & **656** .254 (.42)]

L.M.S.R. Modernished Traffic Control Organisation. — Reprinted from *The Railway Gazette*, May 9th 1947. — A pamphlet (9" × 12") of 12 pages, illustrated. — 1947, London, *The Railway Gazette*, 33, Tothill Street, Westminster, S.W.1. (Price : 2/—.)

This note describes the new organisation adopted by the L.M.S. Railway to direct and control the movement of trains. The organisation consists of placing the part of the railway system concerned under the control of 20 district offices. These are responsible for the running of trains in their area.

A well developed telephone system, a diagrammatic plan of which is given, makes it possible to maintain the necessary communications. In addition to the internal communications in each area, the three divisional managements sharing the authority of the district offices and also the London area can communicate with each other.

The district office communicates di-

rectly with the signal boxes, stations, shunting yards, locomotive and rolling stock sheds, and industrial sidings. To follow train movements, the controllers use cards, one per train, which are moved on a diagram of the section controlled. A train sheet showing the timetables and actual running times makes it possible to analyse any irregularities. The office calls the signal boxes by a general telephone line with a code ring. Inversely, the signal boxes can call the offices by means of selector equipment.

The district offices are responsible not only for the train running, but also the circulation of rolling stock, as well as the steps to be taken to relieve the staff.

The note also gives other very interesting details concerning all the facilities offered by the new telephone equipment, the duties which now fall to the heads of the district offices owing to the policy of decentralization, and the principles employed when investigating the business.

To carry out the programme completely will involve an expenditure of a million pounds. From the experience already gained the Company expects the most happy results therefrom.

E. M.

[625 .611]

BULKELEY (George O. V.), C. B. E., M. I. MECH. E., successively Port Manager, General Manager of Railways, Director of Transport, and Member of Executive Council in the British Colonial Service, in collaboration with SMITH (Ernest J.) F. C. I. S., former Chief Accountant of the Nigerian Government Railways, **Transport Administration in Tropical Dependencies.** — One volume (6" × 9") of 190 pages. — 1946, London, *The Railway Gazette*, 33, Tothill Street, Westminster, S. W. 1. (Price : 1 £.)

The author of this book has had many years experience of dealing with transport in the African Colonies in a managerial capacity. He has also held classes on Transport at Natal Technical College. He is therefore a specialist with a wide experience of his subject.

It is clearly seen in the first chapter that the problems arise in a very different way in the countries concerned. Under the heading « The Transport Characteristic », he gives us an analysis of the traffic which shows us the influence which the railway rates and its equipment can have on the material and moral life of the natives. This chapter and all that follows is steeped in this idea.

In addition the author is preoccupied with the main issues and the administrative and financial structure. This can be seen from the chapter headings which deal in turn with the following questions : the national aspect of transport, services entirely or partially assured by the State, the working of railways, harbours and ports, management and staff, finance and accounts, statistical controls, road transport, waterways, air services, consultative councils, and distribution of traffic. Finally the author defines his conception of the best administrative organisation of transport as a whole in tropical countries.

Very interesting appendices are included for those interested in the technical and financial control of transport undertakings giving the formulae suggested by the author for collecting all the information required to characterize the position and efficiency of such undertakings.

E. M.